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DUODENITIS AND ITS ROENTGENOLOGIC CHARACTERISTICS*

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FOUR years ago I described the roentgenologic manifestations observed in a series of cases of duodenitis, a lesion to which Judd previously had directed particular attention. Since then additional cases have been seen at The Mayo Clinic, and contributions to the subject have been made by several clinicians, pathologists and roentgenologists. This increased material seems to warrant further consideration of the theme.

HISTORY

For many years W. J. Mayo had noted striking differences in the gross appearance of ulcerative lesions of the duodenum, and in 1913 he described them succinctly. He pointed out that certain ulcers, especially those on the anterior wall of the duodenum, often failed to produce definite craters, were not indurated, and could scarcely be palpated through the bowel, if at all. A crater might be represented by a minute slit or dimple in the mucosa, or the entire inflammatory area might resemble a "moth-eaten patch." Later, in a series of papers, Judd more specifically classified duodenal ulcerations in two varieties: First, the true ulcer, which is characterized by a definite crater, an indurated border which is palpable, and hyperemia and stippling of the peritoneal coat. Second, the variety for which Judd proposed the designation duodenitis. This lesion also produces hyperemia and stippling of the serosa, but the wall is not indurated, and on palpation the duodenum is indistinguishable from one which is normal. On opening the bowel the mucosa may appear to be unbroken, but it is locally or diffusely inflamed, bleeds easily on manipulation, and on close inspection may present one or more small, superficial erosions. This variety occurs not only independently but often in association with true ulcer, sometimes in the ulcer bearing area, sometimes on the opposite wall.

MORBID ANATOMY

The morbid anatomic changes of duodenitis were confirmed microscopically in 1924 by MacCarty, who found that it gave rise to cellular destruction, congestion, and edema together with migration of leucocytes, lymphocytes, and endothelial leucocytes. Earlier in the same year Konjetzny had affirmed that in all of 22 cases of duodenal ulcer in which the morbid anatomy was studied, the ulcers were associated with chronic gastritis and duodenitis. From this he inferred that duodenitis is an antecedent of duodenal ulcer, and in ensuing

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papers he vigorously reaffirmed this hypothesis. This view has been endorsed by Nagel, but opposed by Hauser, Büchner and Knötzke, and Radecke.

Wellbrock has studied the histopathology of duodenitis in more than 200 excised specimens comprising instances of simple duodenitis, duodenitis associated with ulceration or erosion, chronic duodenitis, and healed, ulcerated duodenitis. He found that in mild cases the mucosa is infiltrated with a few leucocytes and an occasional polymorphonuclear leucocyte. In addition, there is some congestion of the capillaries, moderate hyperplasia of Brunner's glands, and in certain instances slight thickening, with diffuse fibrosis of the tunica muscularis. In the more advanced, chronic cases these elements are accentuated, plasma cells and eosinophiles are added, the blood vessels are sclerotic, and small erosions of the mucosa with adherent mucus and débris may occur. Despite the increase of fibrous tissue the musculature is not distorted. Inasmuch as similar changes occur in the development of ulcer, Wellbrock expressed the belief that there is a relationship between duodenitis and duodenal ulcer. Of interest in connection with the etiology is a case of duodenitis reported by Rivers, in which cultures from remaining root tips of the patient's teeth were injected intravenously into animals, and duodenitis developed in all within twenty-four hours.

Obviously, the relation between duodenitis and duodenal ulcer, and the causes of both, have not been conclusively determined. However, whether simple duodenitis is an early stage of ulcer or an unrelated entity, distinction between them is nevertheless desirable in selecting appropriate therapeutic measures, and clinicians have shown interest in this phase.

CLINICAL FEATURES

Clinically, Judd was unable to discern any notable differences between the two types, for the symptoms seemed to be alike both in character and duration. At first he was inclined to believe that hemorrhage was rarer and less severe in duodenitis than in ulcer, but later he encountered many cases of duodenitis in which bleeding was grave. Nagel, from a review of 26 cases, concluded that the clinical picture is identical with that of ulcer. Rivers , on reviewing the histories of 82 cases of duodenal ulcer with duodenitis, and 75 cases of nonulcerating duodenitis, found that when duodenitis is associated with ulceration the syndrome is characteristic of ulcer, but he was unable to formulate a syndrome of simple duodenitis. Rivers noted, however, that the pain of duodenitis is likely to be less definitely localized to a small area in the epigastrium than in cases of ulcer, and is often diffusely distributed over the right upper abdominal quadrant. Apparently, also, food and alkalies are not as efficacious in relieving the symptoms as in cases of ulcer. It is noteworthy that hemorrhage occurred in 15 per cent of his cases, and was gross in 12 per cent. Lipschutz, in a report of 10 cases, stated that the typical syndrome of ulcer is frequently observed in duodenitis, making the two conditions indistinguishable clinically, although more recent cases of duodenitis display a syndrome which is rather vague and includes various neurotic manifestations. From a study of 47 cases in which the diagnosis was proved surgically, Hufford gained the impression that the symptoms are less severe than those of ulcer and come later after the meal. Twenty-six cases roentgenologically diagnosed as duodenitis but not verified by surgical exploration were thoroughly analyzed by Miller. He found that the syndrome was not at all distinctive, but in most instances was that commonly associated with peptic ulcer. Sensenich arrived at the conclusion that disturbance of duodenal motility with or without duodenitis may give rise to symptoms simulating those of duodenal ulcer, gallbladder disease, chronic appendicitis, or other gastrointestinal disease. White admitted that inasmuch as hyperchlorhydria is the rule in duodenitis a clinical syndrome suggestive of ulcer is common, but he pointed out that the symp-

toms are not constant, do not occur at fixed hours, and are often accompanied by vomiting, which rarely occurs in cases of ulcer. From these citations it is apparent that despite certain occasional differences in degree or character of the symptoms and signs, clinical distinction of duodenitis from peptic ulcer or even from other affections is at present impracticable.

ROENTGENOLOGIC ASPECTS

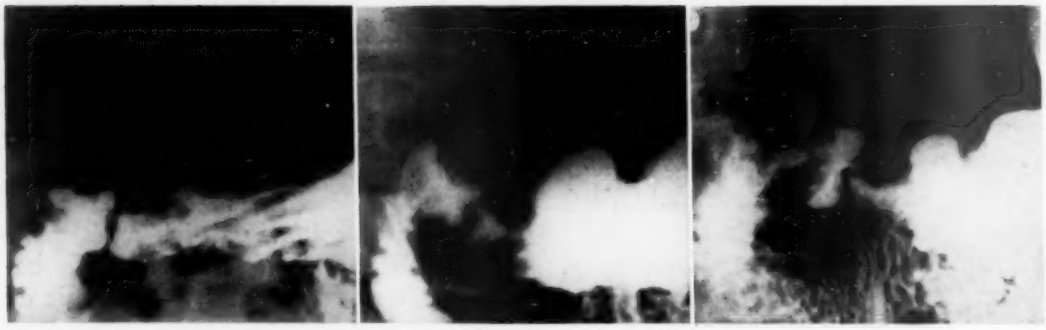
My first paper was based on 45 cases in which duodenitis had been proved by operation to be present but had not previously been diagnosed, either clinically or roentgenologically. From a review of the roentgenologic data in these cases I offered the following as tentative criteria of duodenitis: Irritability of the bulb as shown by rapid emptying and pronounced but unstable deformity, indistinctness of the bulbar contour, absence of a marginal niche or central fleck indicative of a crater, and absence or rarity of gastric retention. As these signs had not been put to proof I warned that they were not presented as definitive but were offered chiefly as a stimulant to further study. Prior to my contribution, as I have learned recently, Eastmond under the title of gastrointestinal infection had described briefly and without illustration certain roentgenologic manifestations of duodenitis. He said that quite commonly the bulbar shadow changes its form from time to time but never assumes the normal, and that along the side corresponding to the lesser curvature minute craters, approximately the size of a match head, may be visible. Lipschutz's 10 cases were characterized roentgenologically by duodenal irritability and hypermotility, indistinctness of the bulbar shadow, and varied spastic phenomena. In Miller's 26 cases inconstant irregularity of the bulbar shadow was the prime roentgenologic feature. Gastric retention occurred in only 3 cases and in 2 of these was slight. Hypertrophied gastric rugae were noted in 3 cases.

In order further to evaluate the roentgenologic manifestations of duodenitis, I have selected for analysis 32 cases observed at The Mayo Clinic from January 1, 1929 to September, 1933. During this period a far greater number was listed under this heading in the files of the Clinic, but the cases I have chosen were instances of simple duodenitis in which an associated ulcer or scar of an ulcer could rigidly be excluded, and in which the pathologic diagnosis was established by microscopic examination of exsected tissue. Except in minor particulars the roentgenologic phenomena observed in this series were identical with those described in my preliminary paper and were in substantial agreement with those reported by other investigators. From this aggregate experience the roentgenologic characteristics of duodenitis can therefore be stated again and with greater confidence as follows:

First in importance among the signs is abnormally increased irritability of the duodenum, although this varies considerably in degree (Fig. 1). Logically it should be in direct ratio to the intensity and extent of the duodenitis, and in certain cases of my series such relationship seemed evident. In typical instances the hyperirritability is manifested in intense spasticity and hypermotility of the duodenum. The barium races through so rapidly that there is scant opportunity to inspect the shadow. The bulb frequently is small and grossly deformed both on its mesial and lateral borders, and the configuration of the deformity varies quickly from moment to moment. Further, the bulbar shadow lacks the density commonly seen in cases of frank ulcer; it is thin and indistinct, and its margins are hazy (Fig. 2).

A second characteristic is the mucosal pattern which is coarsely and irregularly reticular, and is depicted as translucent islets lying in a denser network (Figs. 3 and 4). This appearance is perhaps attributable to puckering of the mucosa by spastic contractions of its muscularis.

A third characteristic of simple duodenitis is the absence of an ulcer crater.



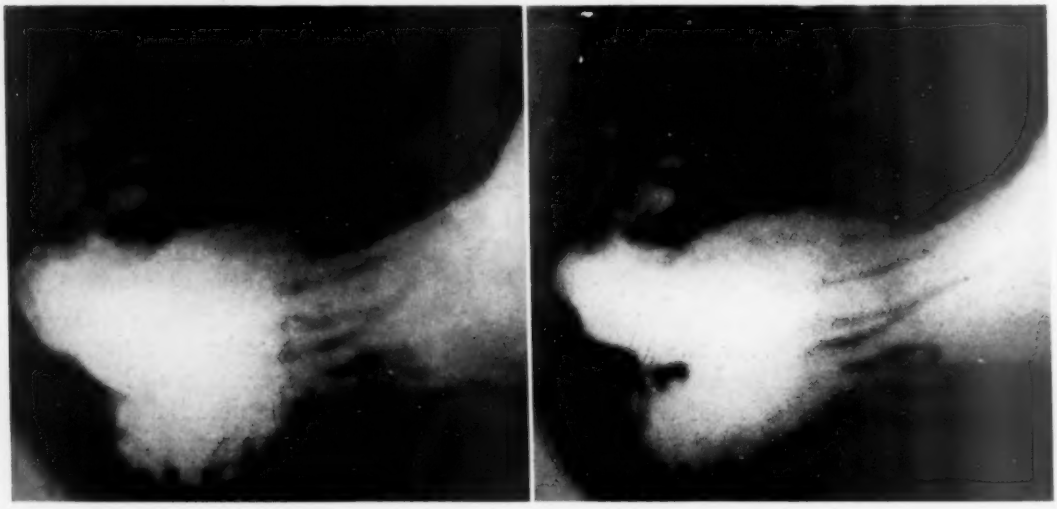
a *b* *c*

FIG. 1, *a*, *b* and *c*. Bulbar deformity, the configuration of which changed from moment to moment during roentgenoscopic observation. Roentgen diagnosis: Duodenitis. Pathologic diagnosis: Duodenitis with hemorrhagic periduodenitis.

Neither marginal niche nor persistent central fleck can be seen.

Finally, uncomplicated duodenitis is marked almost invariably by absence of gastric retention or other evidence of obstruction, whereas such obstruction occurs in more than 25 per cent of cases of true ulcer. It is clear both from roentgenologic and pathologic studies that duodenitis does not tend to produce organic stenosis. Obstruction was absent in all of the 32 cases of the present series. Among the 45 cases of my first series, one case of obstruction was noted, but this was assigned to accompanying hypertrophy of the pyloric muscle. However, such hypertrophy in adults seldom produces gastric retention. In passing, it may be mentioned that hypertrophy of the pyloric muscle was found in 2 cases of the present series.

Completing the typical roentgenologic syndrome of duodenitis is a small, hypertonic stomach with active, sometimes disordered, peristalsis. Like most secondary manifestations, these are not significant except when conjoined with direct signs. It may be that the stomach participates reflexly or directly in the hyperirritability of



a *b*

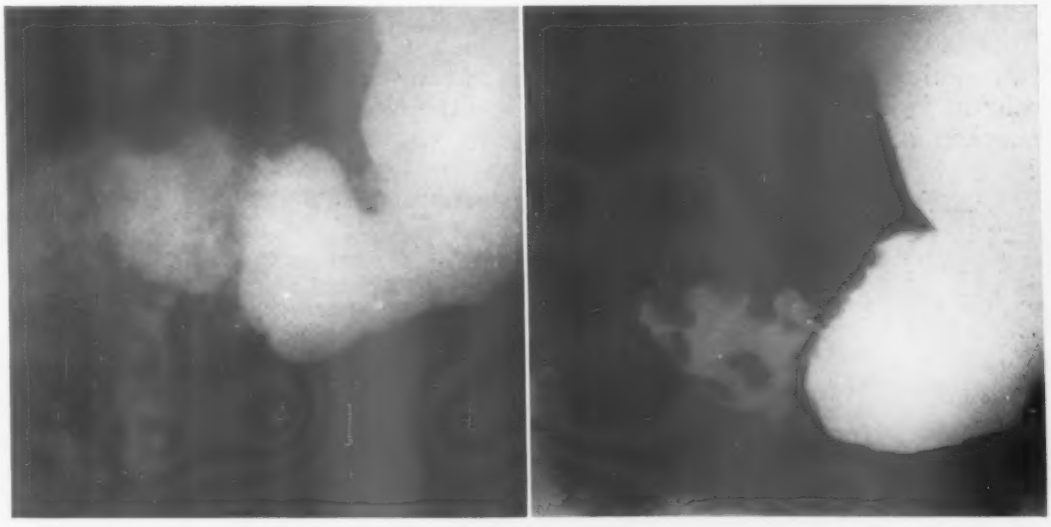
FIG. 2, *a* and *b*. Small deformed bulb with indistinct margins characteristic of duodenitis. The roentgen diagnosis was confirmed by the pathologist.

a *b* *c*

Fig. 3, *a*, *b* and *c*. Coarsely reticular bulbar shadow which changed constantly in size and contour. Roentgen diagnosis: Diffuse duodenitis. Pathologic diagnosis: Chronic duodenitis.

the duodenum, and Konjetzny[9] has found duodenitis and gastritis in common association, but gastritis was not noted by the surgeon in any of the 32 cases of duodenitis.

Like all roentgenologic signs, the foregoing marks of duodenitis vary in emphasis, and only a minority of cases is so typical that the diagnosis is obvious. Thus, among the 32 cases, only 8 were definitely diagnosed as duodenitis, 4 were deemed negative, and a diagnosis of duodenal ulcer was returned in 20. It is noteworthy that among the 4 cases reported as negative the duodenitis was localized to a small area in 2 cases. For almost two decades deformity of the bulb has been recognized as a reliable sign of duodenal ulcer, and this fact probably affected the judgment of the examiner in some of the cases so reported. On the films of certain cases in this group the bulbar deformity was apparently rather stable, for the bulbar shadow was dense and sharply defined, so the errors may have been unavoidable (Fig. 5). It is unlikely that indolent, mild, chronic duodenitis would give rise to an active, fluctuating spasm, and in certain cases of this group the duodenitis was chronic.



a *b*

Fig. 4, *a*. Bulbar deformity typical of duodenitis; *b*, same case fifteen months later, spastic manifestations more pronounced. Roentgen diagnosis at both examinations: Duodenitis, verified by pathologic examination.

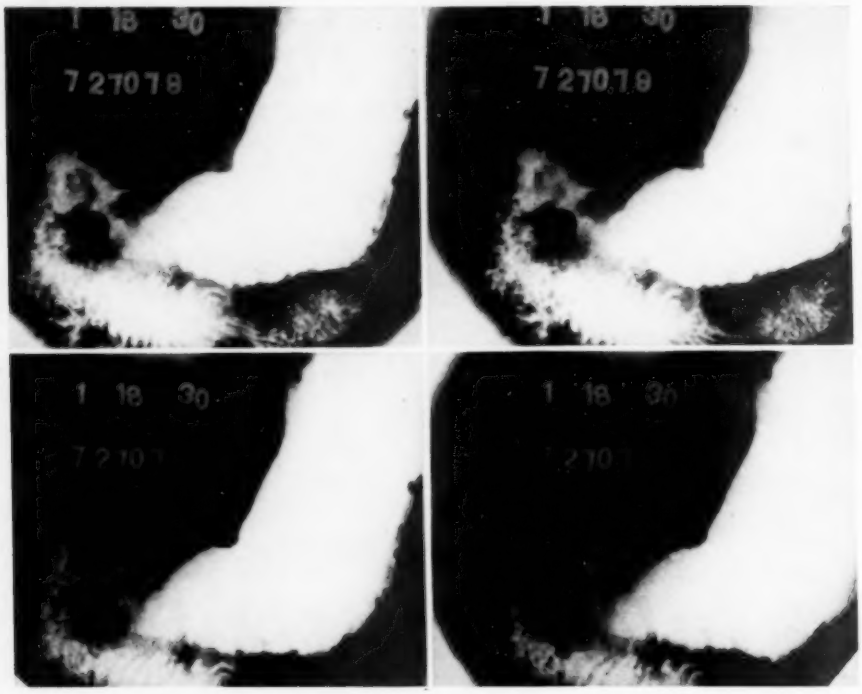


FIG. 5. Constant spastic deformity of the duodenal bulb. Roentgen diagnosis: Duodenal ulcer. At operation a diffuse duodenitis without a true peptic ulcer was found.

In the 8 cases diagnosed roentgenologically and verified macroscopically and microscopically operation was performed, not merely on the basis of the roentgenologic diagnosis, but because severity of symptoms warranted exploration. In this subgroup the symptoms also were of unusually long duration, with an average of more than seven years, and in 3 cases hemorrhage was a feature. During the period covered by the series, 92 roentgenologic diagnoses of duodenitis have been offered, including the 8 proved by operation. Assuming that the diagnoses in the cases in which operation was not performed were generally compatible with the clinical facts, the low ratio of operations is in consonance with the clinical opinion that ordinarily

a *b* *c*

FIG. 6, *a*, *b* and *c*. Marked spastic deformity with some reticulation of the bulbar shadow; this was associated with a central niche, shown in *a* and *b*. Roentgen diagnosis: Duodenal ulcer with diffuse duodenitis, verified by operation.

medical care is preferable for duodenitis. While the diagnostic successes in the proved series may not seem brilliant, they are at least encouraging, and I believe that with further experience they can be increased.

In several cases in which frank ulcer was associated with duodenitis I have been able to identify both lesions at roentgen examination. In these instances the crater of the ulcer could be brought to view, and the rapidly changing extraordinary deformity, which is the essential characteristic of duodenitis, was also present (Fig. 6). Certainly there were many more cases of ulcer, plus duodenitis, in which the combination was not discovered, but I am confident that further cultivation of this field will be profitable.

The direction of progress in roentgenology is not only toward the diagnosis of diseases which have hitherto escaped demonstration by roentgenologic methods but also toward a more complete revelation of morbid anatomic changes in readily demonstrable diseases; such a revelation would be comparable to that afforded by direct inspection of the lesion. Both aims are applicable to study of the duodenum, and it is not unreasonable to expect that eventually the roentgenologist will be able not only to identify active ulcers, scars of ulcer, duodenitis, and their various combinations, but also to determine their exact extent. If and when these distinctions become consistently practicable, the treatment of duodenal lesions will be proportionately advanced.

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ROENTGEN DIAGNOSIS OF CORONARY DISEASE*

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CORONARY disease is one of the more common manifestations of senile involution. Indeed, its occurrence is so frequent as to suggest that part of the changes, at least, are physiological rather than pathological. Its clinical importance, however, depends upon its impairment of cardiac function which may be of long duration and, by virtue of the induced secondary changes, produce sudden death.

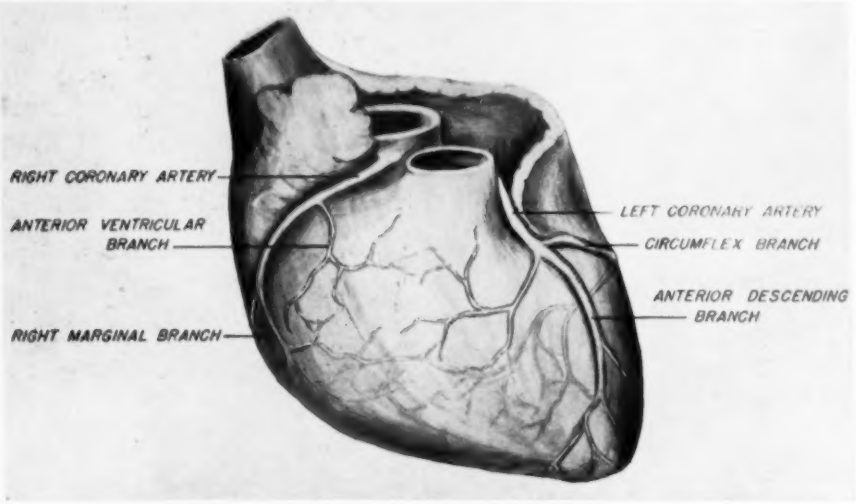

FIG. 1. The coronary arteries (after Cunningham). Note that the circumflex branch of the left coronary artery (which is the one most commonly thrombosed) supplies the lateral border and apex of the left ventricle.

The coronary arteries[1] arise from the aorta: the right, from the anterior, the left, from the posterior aortic sinus.

The right coronary artery (Fig. 1) runs between the root of the pulmonary artery and the right auricle to the coronary sulcus, in which, passing to the right, it encircles the heart until it reaches the posterior end of the inferior interventricular sulcus, where it gives off the right interventricular branch and ends by anastomosing with the circumflex branch of the left coronary artery. The interventricular branch runs forward in the interventricular sulcus supplying both ventricles and anastomosing with the interventricular branch of the left coronary artery.

The left coronary artery runs between the root of the pulmonary artery and the left auricle to the coronary sulcus at the upper end of the anterior interventricular groove and divides into two branches. The anterior decending branch runs down the interventricular sulcus to the apex of the heart, supplying both ventricles and anastomosing with the interventricular branch of the right coronary artery. The circumflex branch runs to the left of the heart, supplying the left auricle, the left margin of the heart and the posterior part of the inferior surface of the left ventricle. It ends by anastomosing with the right coronary artery.

Coronary disease[2,6] is insidious in its onset. The changes, which frequently are associated with similar processes in the aorta and other arterial systems, consist, at first,

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of a thickening of the internal coat by endarteritis. Subsequently, the middle and external coats become involved. The pathological changes may attack all of the coronary vessels, or they may be confined to only one portion of a single artery. *The left circumflex branch is the one most frequently and extensively involved.*

With the formation of a thrombus on the internal coat, the blood supply to the portion of the heart supplied by the diseased vessel becomes seriously impaired. The myocardium in this area becomes at first edematous. Soon, the muscle fibers degenerate and there is an area of localized anemia. In time, an anemic infarct is produced (Fig. 2). If the infarct should become absorbed, the myocardium is left thin and bulging, predisposing to the formation of cardiac aneurysm (Figs. 3 and 4).

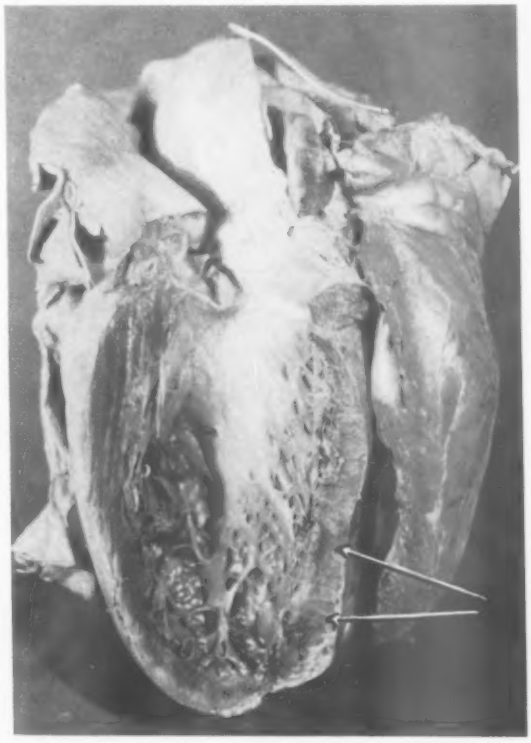

FIG. 2. Photograph showing an area of infarction in the wall of the left ventricle (sectioned). The infarct is the dark portion indicated by arrows. (Courtesy of Dr. C. F. Branch, Boston University School of Medicine.)

FIG. 3. Photograph showing an aneurysm of the left ventricle, seen from behind (arrow). (Courtesy of Dr. C. F. Branch, Boston University School of Medicine.)

Roentgen manifestations of coronary disease are gross visual evidence of its pathological physiology.

The left contour of the heart is formed by the wall of the left ventricle. The convex curve of this portion of the heart is due to two factors: first, a thickening of the left ventricular myocardium which is most marked at the point of greatest curve; second, the tone of the heart muscle, which gives to this portion of the heart its rounded border, much as a contracted biceps muscle produces a prominent convexity. It becomes apparent, therefore, that deficiencies of cardiac tone may be associated with alterations of contour which should be recognizable on the roentgenogram.

The thickness of the left ventricular myocardium[3] is measured fairly approximately by the length of its bisector (Fig. 5). Normally, this value is between 8-10 millimeters.

In ventricular hypertrophy the measure-

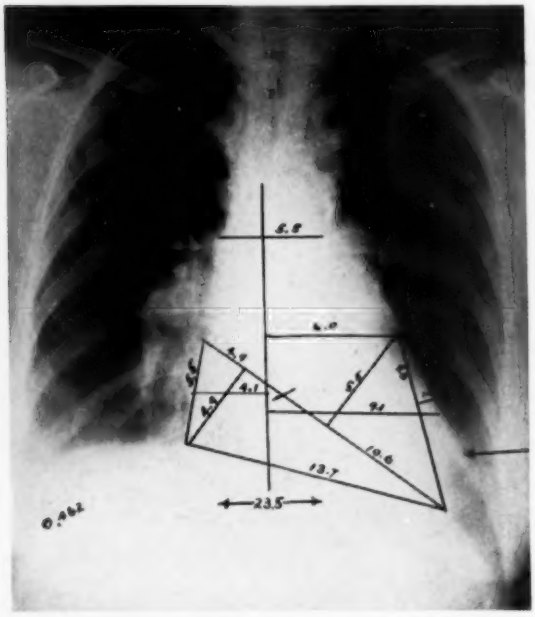

Fig. 4. Roentgenogram of same case as Figure 3. The aneurysm is indicated by arrow. Note the contour of the left border of the heart which is typical of impaired myocardium. Compare with Figure 6.

ment of the bisector increases.[5] This change is likewise observed in cases of increased tone.

The bisector may be regarded as a measurement of the summation of two factors—the thickness and tone of the left ventricle. A diminution of myocardial tone would therefore necessarily reduce the value of the left ventricular bisector.

The typical picture of myocardial impairment produced by coronary disease shows the left border of the heart to be straight or concave, instead of convex. The bisector is small. The right and left median diameters lie almost in the same plane and close to the diaphragm. The heart appears to be "sagged" (Fig. 6).

The changes observed on the film are associated with characteristic roentgenoscopic manifestations (Fig. 7). The amplitude of cardiac contractions is greatly diminished.[4] The type of contraction is typical of an impaired myocardium, and is the determining factor in differentiating other cardiopathies (as the thyrotoxic heart) (Figs. 8 and 9), which produce alterations of cardiac contour simulating the appearance of the heart in myocardial impairment produced by coronary thrombosis.

When coronary thrombosis has been present long enough to produce an infarct, further myocardial impairment results. The portion of the heart most frequently involved is the area supplied by the circumflex coronary artery, so that *the most common site of infarction is the wall of the left ventricle near the apex.*

The roentgenogram in cases of cardiac infarction (Fig. 10) shows no changes other than those observed in coronary thrombosis. Roentgenoscopically, however, in addition to a diminished amplitude of cardiac contractions, one usually observes that *the force of ventricular contractions is even weaker than the force of auricular contractions* (Fig. 11).

In cases of coronary thrombosis with an antecedent history of chronic hypertension, it may at first be difficult to reconcile our description of the heart shadow with what is seen on the roentgenogram. Careful analysis, however, will not only clarify the diag-

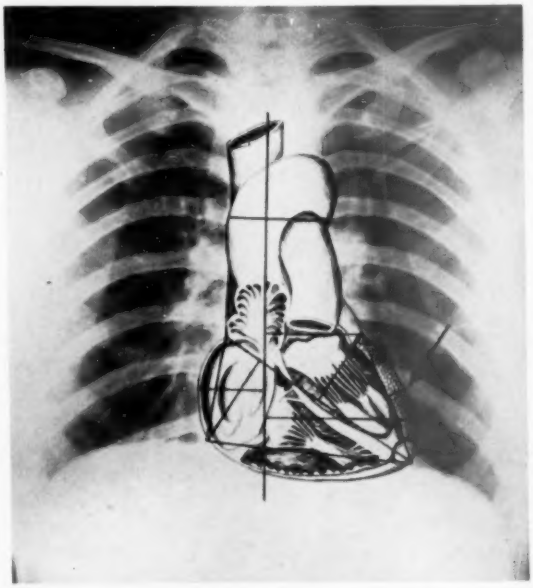

Fig. 5. The *thickness* of the left ventricle is measured by the length of its bisector (indicated by arrow). This thickness is due to the amount and tone of the heart muscle.

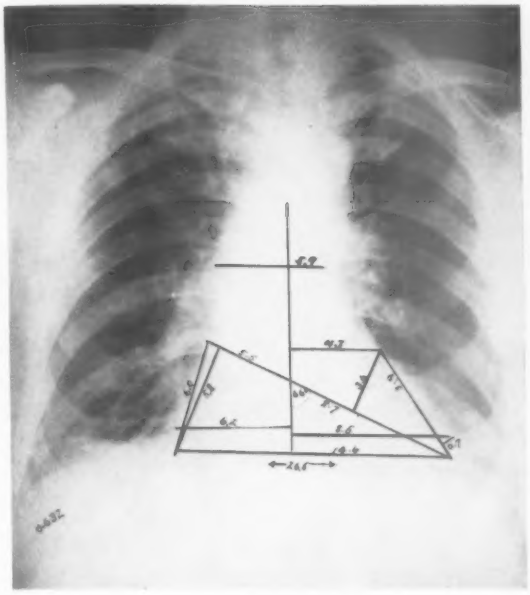

Fig. 6. The typical appearance of the heart in coronary thrombosis. The bisector is small, due to loss of tone, the median diameters lie close to the diaphragm and the heart appears to sag.

nosis but will usually reveal a state of previous hypertension even though the blood pressure may be normal at the time of examination.

The characteristic appearance of the heart in chronic hypertension consists of a thickening of the wall of the left ventricle with a consequent increase in the value of its bisector, and, not infrequently, a functional mitral insufficiency.[5]

When coronary thrombosis or cardiac infarction ensues, important dynamic

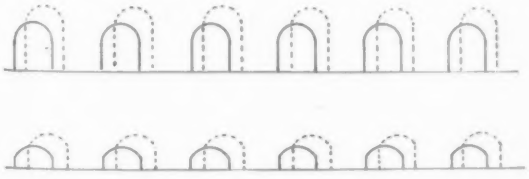

Fig. 7. Schematic representation of the roentgenoscopic appearance of the heart in coronary thrombosis. Solid curves indicate contractions of the auricle; dotted curves indicate contractions of the ventricle. The amplitude or force of these contractions is shown by their height from the base line. Upper line normal; lower line coronary thrombosis.

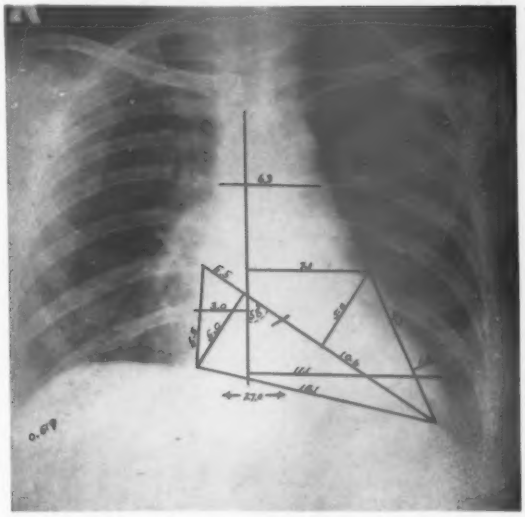

Fig. 8. Typical appearance of thyrotoxic heart. Note how left border simulates the contour of heart in coronary disease (compare with Figs. 4 and 6).

changes are produced which have but little influence on the gross appearance of the heart. Thus, the roentgenogram shows thickening and more or less dilatation of the left ventricle, lasting evidence of chronic hypertension. While the bisector is smaller than it was before the onset of thrombosis, it nevertheless is usually above the normal value (Fig. 12). Roentgenoscopically, however, instead of the vigorous contractions usually seen in hypertension, the amplitude of contractions is greatly diminished. These observations therefore permit the conclusion that there had formerly been hypertension, that coronary thrombosis (with or without cardiac infarction) now exists, impairing the tone of

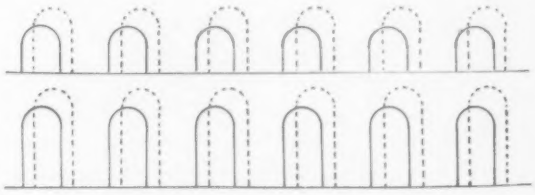

Fig. 9 Schematic representation of the roentgenoscopic appearance of the heart in thyrotoxicosis. Upper line normal; lower line thyrotoxic heart. The latter is characterized by an increase in amplitude of its contractions.

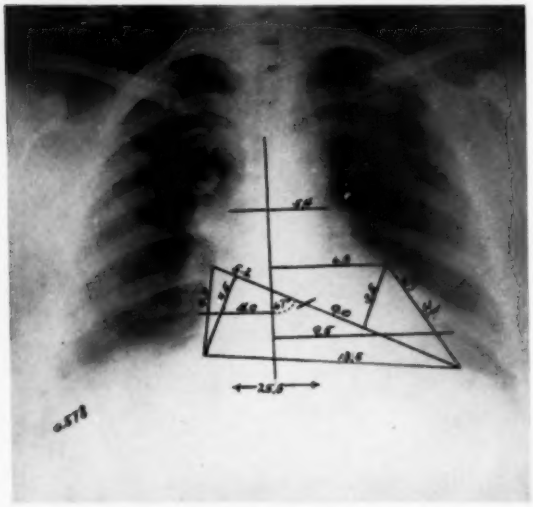

FIG. 10. Appearance of heart in cardiac infarction. The general contour resembles that seen in coronary thrombosis.

the myocardium, as a result of which the blood pressure would, of necessity, decline.

SUMMARY AND CONCLUSIONS

Roentgen diagnosis of coronary disease depends upon the recognition of changes in contour and function of the heart produced by impairment of the myocardium.

The roentgenogram shows a straight or concave left heart border and a small ventricular bisector. The right and left median diameters are almost in the same plane, close to the diaphragm and the heart appears to "sag."

Roentgenoscopically, the amplitude of cardiac contractions is greatly diminished. When infarction has occurred in the wall of the left ventricle, the amplitude of ventricular contractions is less than that of auricular contractions.

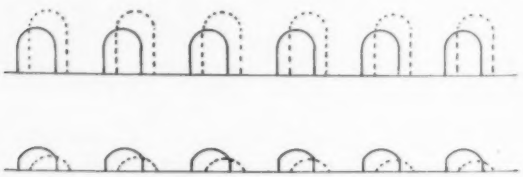

FIG. 11. Schematic representation of the roentgenoscopic appearance of the heart in cardiac infarction. Upper line normal; lower line infarction of left ventricle. The amplitude of ventricular contractions is less than that of the auricle.

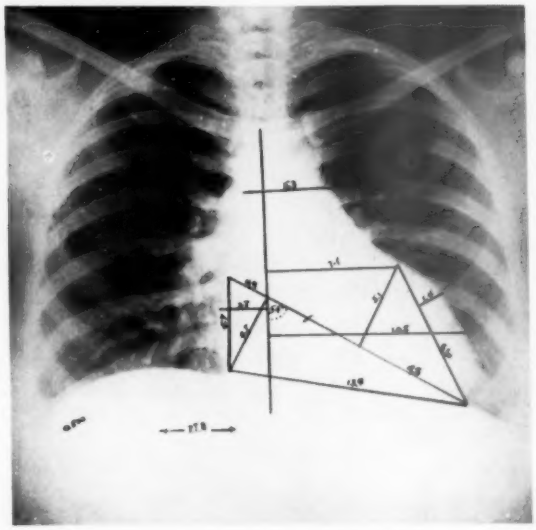

FIG. 12. Coronary thrombosis following chronic hypertension. The typical roentgenographic appearance of myocardial impairment (see Figs. 4 and 6) is lacking. This is due to excessive ventricular hypertrophy resulting from hypertension. The bulging left ventricle of hypertension, however, is replaced by a flattening of its contour. Roentgenoscopically, cardiac contractions are typical of an impaired myocardium (as in Fig. 7).

A pre-existing state of chronic hypertension shows a thickened and more or less dilated left ventricle, associated with the typical roentgenoscopic appearance of diminished amplitude of cardiac contractions.

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Vol. XXXI, No. 5

ROENTGEN EVIDENCE OF EXTENSIVE CALCIFICATION OF THE KIDNEYS IN OSTEITIS FIBROSA CYSTICA*

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LESIONS of the kidneys and the urinary tract in cases of osteitis fibrosa cystica have frequently been reported; especially is the occurrence of renal calculi well known in this disease. In 1931 Hunter and Turnbull[7] collected 32 cases of generalized osteitis fibrosa, in which an adenoma of the parathyroid gland was demonstrated. Ten of these 32 cases had renal calculi. A number of cases have been reported in which calcium metastases were found in different parts of the kidneys only at post mortem. Ask-Upmark[1] reports a case in which calcium deposits in the kidney were proved at autopsy, and Barr and Bulger[2] found calcium metastases in the kidneys associated with large bilateral stones. Hoffheinz,[5] Berner,[3] and Gaugele[4] report similar findings. These calcium metastases are situated chiefly in the cells and in the lumina of the convoluted and collecting tubules. They are also found in the basal membranes of the glomeruli. Because of the small size of the calcium deposits in the kidneys, they can rarely be visualized in living patients, although they can be well demonstrated in a roentgenogram of the isolated organ (Ask-Upmark[1]).

The interesting feature of the case to be reported is that the roentgenogram showed the calcification of the kidneys in a very striking manner in a living patient. Certain associated clinical features are also of interest.

CASE REPORT

J.C., white male, aged thirty-three, was admitted to the Diagnostic Ward of the Boston Dispensary on March 6, 1933. His past history and family history were of no consequence. Only by direct questioning it was learned that the first symptoms which dated from January, 1931, were polyuria and polydipsia. A few months later he began to lose weight and to suffer from pain in his left knee and shin after walking. Easy fatigability and weakness gradually developed and he began to have almost constant headaches. Suddenly in January, 1933, after an acute upper respiratory infection, the pain, which had spread to both legs from hips to toes, became so much worse that he was unable to work. For a few weeks before admission to the hospital, he had to urinate almost every three hours during the day and night. He had to drink water twice during the night. He noticed no blood or pus in his urine. He lost about 32 pounds over a period of two years and his height decreased from 5 feet 6 inches to 5 feet 5 inches.

Physical Examination. Small, pale, undernourished, sick looking man. There was slight pallor of the mucous membranes. The face showed no puffiness, nor was there any palpable edema. The temperature was normal.
Fundi: Normal.
Tongue: Not remarkable.
Neck: An indefinite, bean-sized mass palpated along the medial inferior aspect of the left lobe of the thyroid.
Lungs: Negative.
Heart: Normal in size. There was a soft inconstant systolic murmur over the apex and base. The orthodiagram was within normal limits according to Otten's figures. The pulse was moderately full with rare extra systoles. Blood pressure varied between 115/80 and 125/80.
Abdomen: Liver and spleen not palpable, nor any other masses felt.
Rectal Examination: Negative.
Skeleton: No signs of fractures, all joints freely movable. Slight tenderness on percussion over the right shin. No exostoses and no clubbed fingers.
Nervous System: Reflexes equal and active on both sides and no muscular hypotonia. No abnormal reflexes, sensory changes, or ataxia.

Laboratory Findings. Gastric analysis showed a histamine refractive achlorhydria, very little secretion, but many leucocytes in the fasting contents. (These findings might be due to calcification of the gastric mucosa, such as has been

* From the X-Ray Department and the Medical Clinic of the Boston Dispensary, Dr. J. H. Pratt, Physician-in-Chief.

reported by Barr and Bulger[2] and Jaffe and collaborators.[8])

Stool specimens after meat-free diet were once negative and twice positive by the benzidine and guaiac tests for occult blood.

Basal metabolic rate was minus 6.3 per cent.

Blood: Hemoglobin 60 per cent (Sahli), erythrocytes 3.2 millions per c.mm.; leucocytes 6,100 per cu.mm.; band forms 1 per cent; polymorphonuclear leucocytes 58 per cent; eosinophiles 1 per cent; basophiles 2 per cent; lymphocytes 35 per cent; monocytes 3 per cent.

Non-protein nitrogen, 44.7 mg. in 100 c.c. of blood. Urea 18.1 mg. in 100 c.c. of blood. Sodium chloride 492 mg. in 100 c.c. of serum.

Because of the pains in the legs a roentgen examination of the pelvis was ordered which revealed the diagnosis (see Fig. 2).

Roentgen Report. Pelvis and lumbar spine show extensive osteoporosis with areas suggestive of beginning cyst formation. Fine hazy nodular califications symmetrically placed apparently situated in both kidneys. These findings suggest osteitis fibrosa cystica of von

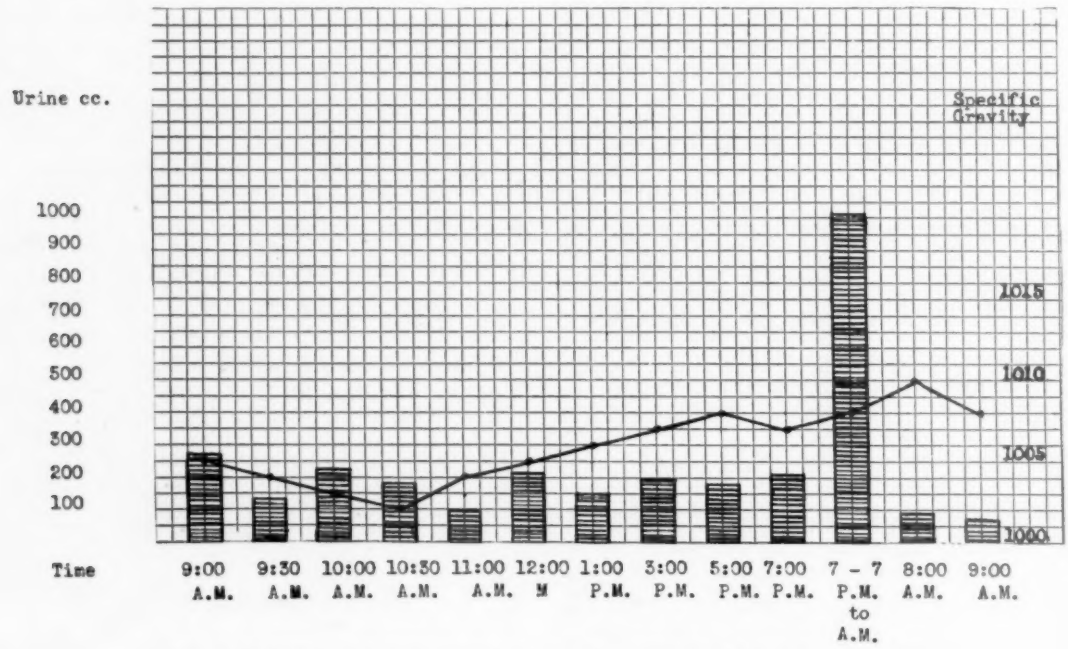

FIG. 1. Dilution and concentration test after intake of 1,000 c.c. of water.

Moderate anisocytosis and achromia. Blood sedimentation rate was 62 mm. in one hour.

Urine: clear, light yellow, slightly acid to neutral, specific gravity 1.010; albumin, slight trace; no Bence-Jones protein; sugar negative; sediment—many leucocytes (about 10 in every field), a few red blood casts, hyaline casts, granular casts and occasionally a red blood corpuscle.

The dilution and concentration test of kidney function gave results as shown in Figure 1. The excretion of phenolsulphonphthalein in the first hour after intravenous injection was 12.5 per cent, in the second hour 25 per cent. Urea clearance test showed 42.0 and 36.9 c.c. of blood cleared from urea in one hour.

Recklinghausen, and therefore kidney and skull films will be made.

Roentgenogram of the kidneys (Fig. 3) shows innumerable areas of increased density each about the size of a millet-seed lying in wedge-shaped forms, conforming to the outlines of the kidney pyramids. The skull (Fig. 4) shows a mottled appearance due to small areas of decreased and increased density. The calcium content of the skull seems markedly decreased. Apparently the lower jaw and all the bones of the face are involved in the osteoporotic process. The rest of the long bones showed the same findings in varying degrees. There was no evidence of calcification in the lungs.

Diagnosis. Osteitis fibrosa cystica with ex-

Fig. 2. Osteoporosis in pelvis and lumbar spine. Fine, hazy, nodular calcifications in both kidneys.

tensive calcification of the parenchyma of the kidneys.

The following confirmatory findings were then obtained:

Fig. 3. Calcifications of the kidneys in wedge-shaped form, conforming to the outline of the kidney pyramids.

Calcium 16.9 mg. per 100 c.c. of serum. Phosphorus, 3.0 mg. per 100 c.c. of serum. (We are indebted to Dr. W. Bauer of the Massachusetts General Hospital for these examinations.)

At the suggestion of Dr. H. E. MacMahon, professor of pathology at Tufts Medical School, a special examination of the urinary sediment was made which showed the following:

Urine Sediment—Stained with silver nitrate, shows calcium in fine and coarse granules, free and impregnating necrotic cells. Stained with hematoxylin and eosin it shows many polymorphonuclear leucocytes, cellular casts, few red blood cells, and calcium as granules and coarse tangled threads.

Fig. 4. The skull shows a mottled appearance due to small areas of decreased and increased density.

The patient was transferred to the Massachusetts General Hospital, Boston. At operation Dr. E. D. Churchill removed a bean-sized parathyroid adenoma from the left side of the neck. The patient made a good recovery.

Further reports of the patient's condition will be given by Dr. W. Bauer of the Massachusetts General Hospital at a later date.

DISCUSSION

We may assume, from the roentgen examination, that most of the calcium metastases are situated in the region of the collecting tubules. The autopsy findings, which have been reported in the literature would seem to support this opinion. In this connection the experiments of Hueper[6] and Jaffe, Bodansky and Blair[8] are of in-

terest. They found in dogs which were poisoned with parathyroid hormone no macroscopic, but extensive microscopic areas of calcification. Calcium was found in the epithelium and the basal membranes of the convoluted tubules of the kidneys, in the epithelium and lumen of the collecting tubules and in the membranes of Bowman's capsules.

The urinary findings in our case were chiefly as follows: polyuria, hyposthenuria, albuminuria, many leucocytes, hyaline and granular casts in the sediment and also calcium impregnated cells, diminished urea clearance and phenolsulphonphthalein excretion. However, no retinal changes and no nitrogen retention in the blood were present, neither was there hypertension or edema. These findings together with the roentgen picture demonstrate the peculiarity of this kind of hematogenous kidney lesion, which does not fall into the known forms of Bright's disease.

The initial polyuria is generally believed to be caused by the high calcium output through the kidneys. According to Ask-Upmark and other authors, it may be the expression of a diuretic effect of the parathyroid hormone, but others claim that polyuria in osteitis fibrosa cystica is a true diabetes insipidus. However, there is very little evidence for the latter opinion. That the hyperparathyroidism is really the cause of the polyuria, whatever its mechanism may be, is proved by the fact that removal of the tumor has been observed in several cases to be promptly followed by the disappearance of polydipsia and polyuria.

SUMMARY

1. A case of osteitis fibrosa cystica is presented in which an early diagnosis was possible before clinical evidence of bony changes was obvious.

2. There was roentgen evidence of extensive parenchymatous calcification of both kidneys.

3. The clinical findings in the kidney were those of a peculiar form of hematogenous kidney disease.

4. The diagnosis of parathyroid adenoma was proved by operation and the tumor successfully removed.

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Vol. XXXI, No. 5

THE ROENTGEN RAY AS AN AID IN THE DIAGNOSIS OF HEMOPHILIA*

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"BLEEDERS" have apparently been known of for centuries. Albucasis, in 1590, reported that in a certain village were men, who, when wounded, suffered uncontrollable hemorrhages which caused death. The disease was first recognized as a clinical entity in 1803 when Dr. John C. Otto published an account of a hemorrhagic condition existing in certain families.[4]

Hemophilia is supposed to be a recessive characteristic, and females should be affected in proportion of one female to two hundred males who have the disease. In 1820 Masse stated, "Men alone are subject to hemophilia, and the disease is transmitted by normal females by their marriage to normal males" (Witts[14]). Kugelmass[10] makes the same type of statement, and adds, "It may be dormant from any generation, only to reappear in a remote male descendant." Also, that it is the most heritable of the hereditary diseases. It is interesting that no definite evidence has ever been gathered to show that true hemophilia is ever observed in women (Bauer and Wehefritz[2]).

The diagnosis of hemophilia is presented in standard texts of medicine. An excellent article on the subject is one by Kugelmass,[10] in which he states, "Prolonged clotting time alone is never pathognomonic of hemophilia." He does not feel that hemophilia is a very common disorder, while "bleeders" are. In this respect he quotes Bulloch and Fildes of the London Eugenic Laboratory, who have been able to authenticate only 44 hemophilic families out of 273 reported in a century of literature.

I wish to present 3 cases of hemophilia, with comments on other cases in the literature, which, in my opinion, all showed characteristic changes in the roentgenograms.

CASE I. E. R., male, white, aged twenty-six. Admitted to the University Hospital, November 2, 1929, on the Medical Service of Dr. Fred M. Smith. Patient's history dated from the age of four years, when he had had attacks of swelling and stiffness of joints, brought on by trauma. His nose had always bled extremely readily, and wounds of any type would bleed profusely. An uncle on his father's side bled to death at the age of twenty-one. No other family history of bleeding could be obtained.

Examination on entrance revealed legs somewhat atrophied, both knees distorted in shape, swollen and flexed at an angle of 20°.

Laboratory Data. Coagulation time was twelve minutes, and there was no retractability of the clot in four hours. Platelets, 0.6 per cent; red blood cells, 4,080,000; blood negative otherwise. Patient's condition showed exacerbations and remissions. In February, 1931, he was put on ovarian extract, 5 grains, t.i.d. by mouth. In January, 1933, patient was feeling well, having had no bleeding, except for two days of hematuria, and that not very recently. Examination in January, 1933, showed some swelling of the left knee and tenderness, but practically no loss of function.

Roentgen examination of both knees in November, 1929, revealed narrowing of the joint spaces, a marked proliferation of the lateral condyles of both femora and tibiae, with very marked widening and deepening of the intercondylar fossae of both knees. There was also sharpening of the intercondylar ridge of both tibiae. Roentgen examination of both elbows showed marked flattening and enlargement of the head of each radius. There were also suggestive arthritic changes (Figs. 1 and 2). Roentgenograms made in January, 1933, showed no additional changes.

CASE II. Male, white, aged twelve. Admitted, as a private patient of Dr. Arthur Steindler, to the University Hospital on September 5, 1931, with history dating back two and one-half years, when he injured lower lip, which bled moderately but stopped spontaneously.

* From the Department of Roentgenology, State University of Iowa.

Two days later lip bled spontaneously and was stopped by suturing and injections of serum. Since then any bruise would cause severe subcutaneous hemorrhages. Three years ago he bumped his left knee. The knee swelled and became flexed at a 90° angle. Extension was applied and the deformity quickly corrected. On examination, left knee could not be fully extended, but could be flexed to 100°. There were numerous subcutaneous discolorations of both lower and upper extremities.

Clotting time varied from nine minutes to two and one-half hours. No other blood examination done. No therapy given.

Roentgen examination revealed a normal appearing right knee, but marked changes in the left knee. Characteristically, there was widening and deepening of the intercondylar fossa, some narrowing of the joint space, and marked osteoporosis of both the left femur and the left tibia. No evidence of any proliferation (see Fig. 3).

CASE III. Male, white, aged eleven. Admitted to University Hospital September 14, 1931, on the Pediatric Service of Dr. P. C. Jeans. At four months of age patient bruised very readily. At the age of two years had frequent nose bleeds, lasting as long as three days. At three and one-half years had symptoms suggestive of intermittent bleeding of joints. At the age of five years had corrective treatment for contracted legs, and has been forced to use crutches ever since. No family history of bleeding.

Examination revealed ecchymoses of both elbows, and both knees, extending down the legs. Both knees were limited in motion and painful. Coagulation time was forty minutes, by Howe's method. Clot retraction one and one-half hours; platelets, 270,000; red blood cells, 3,470,000. Was given ovarian extract. There was some improvement, as the coagulation time dropped to fourteen minutes, by capillary method, but clot retraction was still one and one-half hours.

FIG. 1. Case I. Anteroposterior views of both elbows showing widening of the head of each radius.

Roentgen examination on September 16, 1931 (Fig. 4), showed marked changes in the left knee joint, characterized by some widening and deepening of the intercondylar fossa, and osteoporosis of both the left femur and the left tibia.

DISCUSSION

A review of the reproductions of the roentgenograms shown in the article by Wilson[13] and those by Key,[8] Heigl,[6] and Reinecke and Wohlwill[12] also revealed marked widening and deepening of the intercondylar fossa, with arthritic changes in the remainder of the joint. These changes were noted by the above authors, except Wilson, and were stressed by Key, Reinecke and Wohlwill, and Klason.[9] Klason reports 3 cases, and in all of these there is marked widening and deepening of the intercondylar fossa.

An explanation for the widening and deepening of the intercondylar fossa in this condition is not so easy. We know that the blood supply in the knee joint enters at the intercondylar fossa. Klason considers that bleeding occurs at the point of attachments of the crucial ligaments, at the apex of the intercondylar fossa. It is known that bleeding causes bone deterioration, and it is conceivable that the pressure from the bleeding would cause erosion, at this point, since at the apex of the intercondylar fossa there is no cartilage. However, Key[8] believes that possibly intra-osseous hemor-

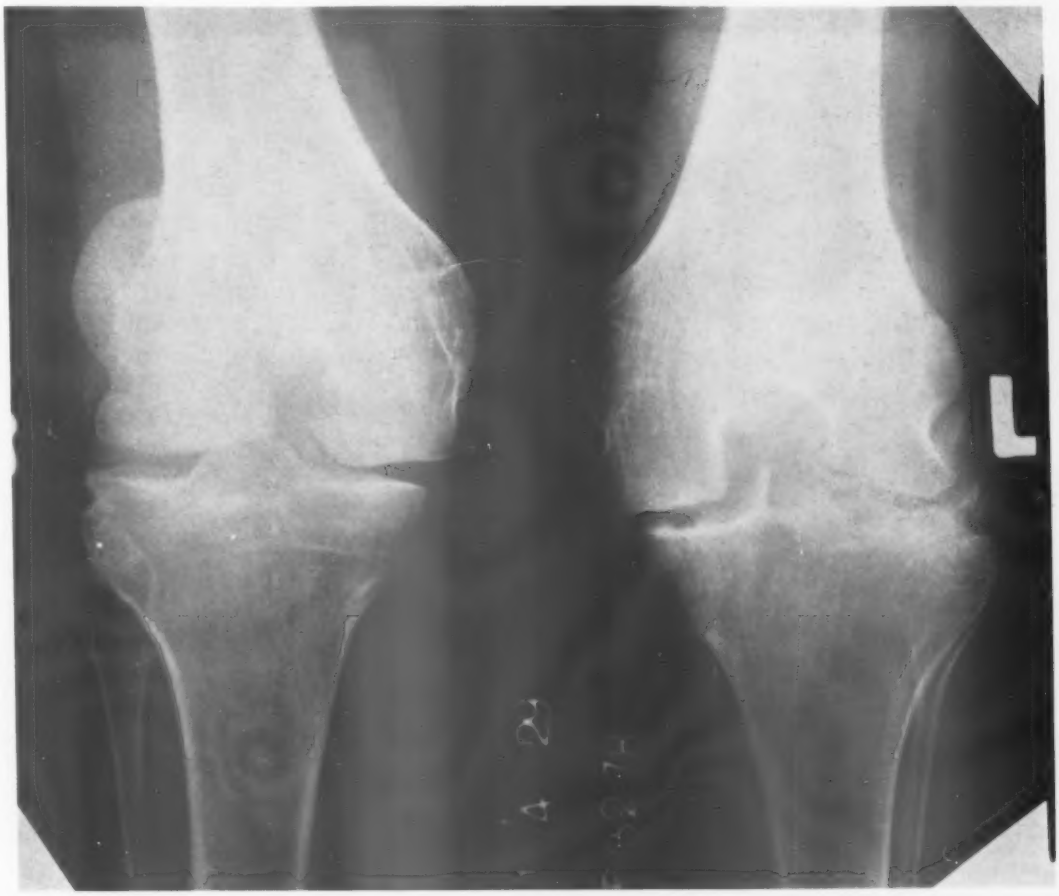

Fig. 2. Case 1. Anteroposterior views of both knees showing marked widening and deepening of the intercondylar fossae, with definite arthritic changes.

rhage plays an important part. Although the pressure idea is an exceedingly simple explanation, we do not see why other effusions, chronic in nature, could not bring about the same condition. While in tuberculosis of the knee joint there may be some widening and deepening of the intercondylar fossa, yet it does not reach the extent that leucocytes and macrophages, although the tissues return to normal in six days. However, repeated injections of blood would cause markedly thickened synovial membrane.

As Fisher[5] has pointed out, the lateral part of the articular cartilage is better nourished than the central part. Thus, it

FIG. 3. Case II. Anteroposterior views of both knees showing osteoporosis of the right femur and tibia, with widening and deepening of the left intercondylar fossa.

it does in hemophilia, and there is apt to be more destruction of cartilage.

Proliferative changes are readily explained by the receding hemorrhages. Key[7] has well demonstrated that injection of blood into a normal knee joint causes mild proliferation of the synovial lining cells and infiltration of the subsynovial tissue with

is possible to produce, experimentally, a traumatic form of osteoarthritis, by the simple expedient of removing the central part of the articular cartilage, whereupon compensatory proliferation of the better nourished lateral area occurs, producing characteristic lipping. This could be used to explain changes following the destruc-

tion of the central portion of the cartilage as a result of pressure from the effusion.

Since trauma is supposed to be the exciting cause of the hemorrhages, the knee joint is the most logical to study, as it, of course, is more exposed to trauma, and apt to show the more advanced changes.

DIFFERENTIAL DIAGNOSIS

Tuberculosis of the knee joint is apt to cause far more destruction and practically no proliferation (Baetjer and Waters[1]).

Purpura hemorrhagica sometimes causes bleeding into the knee joint, but apparently does not cause enough bleeding to bring about changes demonstrable in the roentgenogram.

Low-grade infectious arthritis may cause widening and deepening of the intercondylar fossa, although not commonly, but in this type of condition, in the cases which we observed, there is apparently no proliferation.

The hereditary history and the ordinary laboratory findings would, of course, tend to rule out other conditions.

Klason[9] considers the enlargement and widening of the intercondylar fossa as being an especially distinct feature of hemophilia.

TREATMENT

Ovarian extract has apparently given excellent results (Birch[3]) and in the one case of ours, in which it has been used, the patient has done remarkably well. It is interesting to note that Minot and Lee[11] quote Heuffer, who reports that irradiation of the spleen has given some temporary benefit, on the basis that thrombokinase has been liberated.

Fig. 4. Case III. Anteroposterior views of both knees showing osteoporosis of the left femur and tibia, with widening and some deepening of the left intercondylar fossa.

SUMMARY

1. Three cases of hemophilia are report-

ed; all show definite changes in knee joints.

2. We believe that widening and deepening of the intercondylar fossa, with or without arthritic changes in the knee joint, in a member of the male sex is characteristic of hemophilia.

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Vol. XXXI, No. 5

DIVERTICULUM OF THE GALLBLADDER*

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PHILADELPHIA, PENNSYLVANIA

DIVERTICULUM of the gallbladder is not an uncommon finding at operation or autopsy. Courvoisier, Staub, Kehr, Dévé, Weltz, Deaver and Ashhurst, Schachner, Sebening and Schöndube, Abbott, and others, have reported the condition. Rolleston and McNee have discussed the subject in their recent book. In spite of the relative frequency of its occurrence, a preoperative diagnosis of diverticulum of the gallbladder is rarely made. Bársony, in 1927, and, Bársony and von Friedrich, in 1928, reported a case of diverticulum of the gallbladder in which the diagnosis made by cholecystography was confirmed at operation. They stated that, according to their knowledge, there had not been a similar case reported in which a diagnosis of diverticulum had been made by cholecystography and had been confirmed.

The etiology of this condition is uncertain. Rolleston and McNee suggest ulceration with consequent weakening of the wall as a possible causative agent. Courvoisier reported a diverticulum which was apparently due to traction. That diverticula of the gallbladder are congenital is remotely possible. Schachner classed them as congenital anomalies. Sebening and Schöndube reported a diverticulum of the gallbladder of sufficient size to interfere with emptying of the stomach. Deaver and Ashhurst reported a diverticulum of the gallbladder large enough to press on the common duct and cause obstructive jaundice. Rokitansky, in 1842, first described "small, saccular dilatations of the biliary mucous membrane" in which "small calculi are occasionally found and which may appear to lie external to the cavity of the gallbladder." Halpert has fully discussed these hernia-like outpouchings of the gallbladder mucosa. They are generally about the size of a millet seed or hemp seed and usually occur in large numbers. That one of these "Rokitansky pouches" enlarges and is the beginning of a diverticulum is not beyond the realm of possibility. Numerous "Rokitansky-Aschoff sinuses" were reported by Dr. Helen Ingelby in one of the cases here presented and these are suggested as a possible etiological factor.

CASE REPORTS

Two cases are here presented in which the diagnosis of diverticulum of the gallbladder was made.

CASE 1. Mrs. A. J., white, aged thirty-eight, was referred to the Women's College Hospital for cholecystography by Dr. Mary M. Spears. Her chief complaints were distress in the epigastrium and right hypochondrium following the ingestion of food. There was no nausea nor vomiting. She was slightly constipated and had considerable flatulence. Her present illness began a year previous to admission. Her past history and family history are irrelevant. Physical examination revealed definite tenderness in the epigastrium and right hypochondrium. There were no other significant findings upon physical examination. Dr. Spears diagnosed biliary infection by transduodenal gallbladder drainage. Roentgen examination of the gastrointestinal tract was essentially negative.

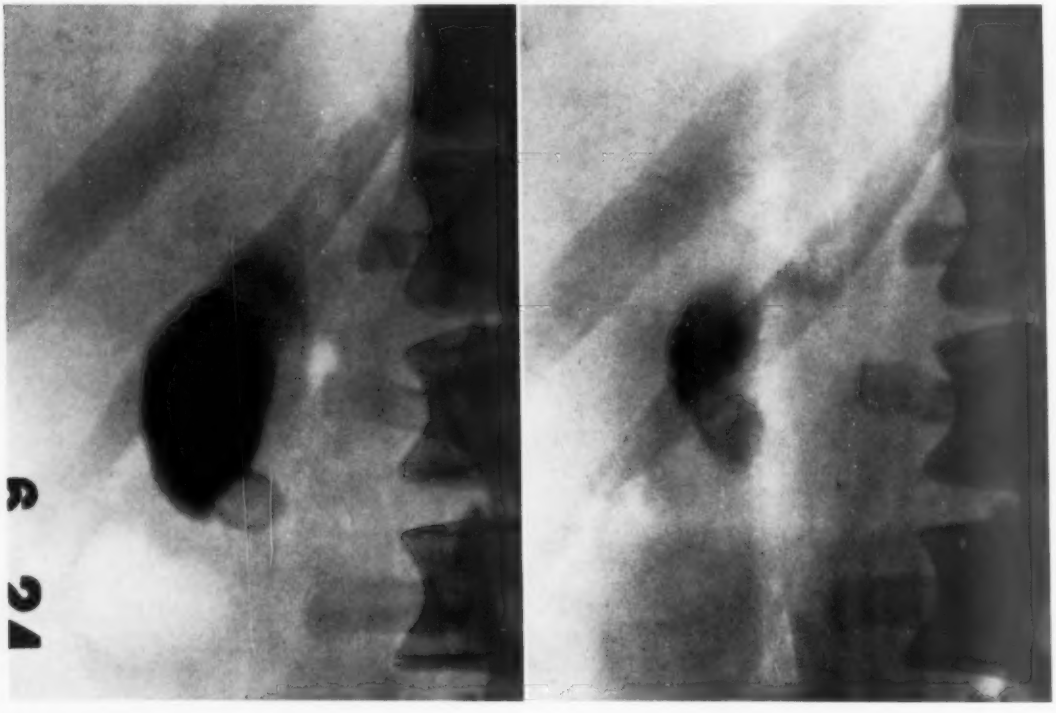
The report on the gallbladder is as follows: "Intravenous cholecystograms show a dense homogeneous gallbladder shadow at sixteen hours after the administration of the opaque salt. There is a single positive shadow adjoining the fundus of the gallbladder approximately 1 cm. in diameter which is characteristic in appearance of a gallstone. There is an indentation of the fundus of the gallbladder adjoining this calculus and it is probable that the calculus is in a diverticulum from the fundus of the gallbladder." (Fig. 1.)

A cholecystectomy was performed by Dr. J. Stewart Rodman and the pathological report of the removed gallbladder is as follows: "The specimen (Fig. 2) consists of a gallbladder 7

* Read before the Philadelphia Roentgen Ray Society, January 28, 1933.

cm. long and 1.5 cm. in diamerer. The serosa is greenish. The wall is thickened and granular and stained green. The portion of the cystic duct present is patent. In the fundus of the bladder there is an outpouching 1.3 cm. in diameter, the wall of which is thinned out. The stone is 1.0 cm. in diameter and is black and roughened. *Microscopic:* The villi are short and thick. *There are many outpouchings of the mucosa between the muscle bundles of the midde coat: 'Rokitansky-Aschoff sinuses.'* Many of the villi contain dilated vessels. Chronic inflammatory cells are scattered throughout the mucosa. The vessels of the perimuscular connective tissue layer are dilated; in this layer there are a few chronic inflammatory cells. In sections taken through the pouch and the adjoining gallbladder wall the muscle appears hypertrophied on either side of the pouch. The pouch itself shows a very thin wall with no crypts. The epithelium is shed. The wall consists of a narrow band of fibrous tissue outside of which is a little fat. No muscular fibers are present in the thin wall of the pouch"—Dr. Helen Ingelby.

It is interesting to note in the pathological report that there were many outpouchings of the mucosa between the muscle bundles of the middle coat. The possibility that one of these "Rokitansky-Aschoff sinuses" was a beginning of the diverticulum should be considered. Preoperative diagnosis is most important in those cases of diverticulum containing calculi since one's first impulse in employing cholecystography to differentiate between renal and biliary calculi might be to interpret a positive shadow lying wholly outside the lumen of the gallbladder as being situated in the kidney. The diagnostic features of a calculus in a diverticulum of the gallbladder according to my observations are: (1) its



A B

Fig. 1. Case 1. Diverticulum of the gallbladder containing a calculus. A—Cholecystogram made fourteen hours after intravenous administration of the opaque salt. B—Roentgenogram taken forty-five minutes after a fat-rich meal showing the constant relation of the diverticulum and calculus to the gallbladder shadow.

constant relation to the gallbladder shadow in all positions in the filled and partially empty gallbladder; (2) the presence of a slight indentation in the outline of the gallbladder adjoining the shadow of the calculus or the diverticulum; (3) the frequently laminated appearance or negative center of the calculus.

Case II. Mrs. J. K., white, aged fifty-eight, was referred to the Women's College Hospital by Dr. Wilfrid B. Fetterman for cholecystography. Her chief complaint was "indigestion" over a period of years. She had considerable gas and frequent soft pasty stools. She had occasional arthritic pains in different joints. Other foci of infection were excluded and the gallbladder was under suspicion as a possible focus of infection. The roentgen report on the gallbladder is as follows: "Intravenous cholecystograms show a rather faint homogeneous gallbladder shadow fourteen hours after administration of the opaque salt. There is a separate shadow approximately 1 cm. in diameter adjoining the fundus of the gallbladder which suggests the appearance of a diverticulum. The gallbladder shadow was diminished in size following a fat-rich meal. There is no evidence of calculus. The faint gallbladder shadow following the intravenous administration of the dye indicates cholecystitis." (Fig. 3.) Operation was not advised and the findings have not been confirmed. These cholecystograms correspond in regard to both size and position of the so-diagnosed diverticulum with those of the case reported by Bársony and von Friedrich, which case was confirmed by operation.

Fig. 3. Case II. Intravenous cholecystogram in which the shadow projecting from the fundus of the gallbladder was diagnosed as a diverticulum. The diminished density of the shadow by the intravenous method indicates cholecystitis. These cholecystograms correspond closely with those in the case of diverticulum of the gallbladder reported by Bársony and von Friedrich.

Fig. 2. Case I. Gallbladder from case illustrated in Figure 1, after removal, showing the opening of the diverticulum.

Diagnosis of diverticulum of the gallbladder preoperatively can obviously only be made by cholecystography. If a diverticulum is so diagnosed in an otherwise not abnormal gallbladder it is of little probable significance although this assertion is open to question as shown by Abbott's case in which he found an inflamed diverticulum projecting from an otherwise normal gallbladder.

Differentiation of diverticulum of the gallbladder must be made from: (1) congenital malformations such as double gallbladder, as reported by Schachner, Nichols, Boyden and many others; (2) hour-glass gallbladder, as reported by Courvoisier, Hartmann, Malcolm, Morton, Toida, and others. Levine diagnosed the presence of

an hour-glass gallbladder by cholecystography; (3) redundant gallbladder due to the presence of a peritoneal fold—the cystoduodenal or cystocolic ligament. Flint has described this as an abnormality, not a pathological change; (4) pericholecystic adhesions causing deformity of an otherwise normal gallbladder shadow.

The differentiation between the above conditions and diverticulum should be made easier by films taken at different angles in some of which the redundant or double gallbladder shadows can be shown in a position in which there is no overlapping. There are not sufficient cases recorded to establish definite diagnostic features but the findings in our cases would suggest that roentgenograms taken following a fat-rich meal show less decrease in size in the diverticulum due to the absence of muscle fibers in the wall of the diverticulum.

SUMMARY

Two cases are reported in which a diagnosis of diverticulum of the gallbladder was made by intravenous cholecystography. One case corresponded to that reported by Bársony and von Friedrich, but confirmation has not as yet been obtained. In the other case a calculus was present in the diverticulum, which since it was entirely outside the gallbladder shadow might easily be mistaken for a renal calculus. No similar case could be found in the literature in which a preoperative diagnosis had been made. A review of the literature revealed numerous case reports of diverticula of the gallbladder but only one case report in which there was a preoperative diagnosis of diverticulum of the gallbladder.

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ROENTGEN DIAGNOSIS OF DISEASES OF THE COLON

AN EVALUATION OF METHODS*

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THE IDEA of artificially inducing a relative difference in density between the intestinal tube and the tissues surrounding it, thereby enhancing its roentgenologic contrast, arose soon after Röntgen's discovery was announced. Becher, in 1896, made roentgenograms of the stomach and isolated loops of the large intestine after filling them with a solution of lead acetate, as well as after inflating them with air. At this early date Becher used both extremes of the contrast scale to visualize the lumen of the alimentary tube, employing a solution of a salt of a heavy metal to impede, and a gas to promote, the passage of the roentgen rays through these viscera. But the notion of using the salts of heavy metals as contrast materials seems not to have been original with Becher, for late in 1896 Cannon was already demonstrating the phenomena of deglutition exhibited by the goose when swallowing capsules filled with bismuth subnitrate, and Rumpel had visualized a dilated esophagus, using a suspension of this material. Rumpel was apparently the first to use a suspension of a metallic contrast substance to visualize a portion of the alimentary tract of man.

The earliest and most widely known observations, those of Cannon,[6,7] Roux, and Balthazard and Williams were concerned largely with the esophagus and stomach, although Williams suggested the use of gas for outlining the sigmoid and descending portion of the colon at least as early as 1901. By this time Hildebrand and Rumpel actually had visualized the colon of the human being in vivo. They administered large quantities of bismuth orally for several days, gave opium to quiet the intestine and facilitate the formation of opaque fecal masses, and made roentgenograms just after insufflation with air. Hildebrand commented on the clearness of the roentgenograms so obtained. Thus it appears that a combined method actually had been used before the single contrast method by means of an opaque enema had been developed. However, in the same publication in which the description of these observations appeared, Hildebrand inferred that he also had made the colon of the human being visible by injecting a suspension of bismuth salt into it by rectum.

By 1902 Cannon[7] had extended his roentgenologic observations on the movements of esophagus and stomach of animals to include the movements of the intestines. Animals were used also in the studies of Kraus and of Lommel. It seems to have been the appearance of the work of Rieder,[27,28] however, which gave impetus to a much more general and intensive application of roentgen rays to study of the anatomy, physiology, and pathology of the digestive tract. Although Rieder and Schüle used the opaque enema in their studies, most of the early observations of the colon were made with the contrast meal. Before Haenisch had demonstrated the superiority of the roentgenoscopically observed contrast enema over the contrast meal for all purposes except study of the motor function of the colon, Pfahler had recommended, and Cole and Einhorn had submitted actual experience with the use of air to make the large intestine demonstrable roentgenologically. Krauss, and later Burkhardt, substituted oxygen for air, and carbon dioxide was suggested and used by others.

Haenisch's first publication appeared in 1911, and thereafter no noteworthy devel-

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opments in method appeared until 1923, when Fischer[13] described his recently elaborated combined method. Mention should be made, however, of the substitution of the sulphate salt of barium for the insoluble salts of bismuth which took place between 1911 and 1923. Case, in 1911, pointed out the advantages of stereoroentgenography of the colon filled with opaque material for more definite demonstration of certain significant roentgenologic evidences of abnormality. Between 1911 and 1923 most investigators who were consistently interested in the large intestine were occupied chiefly with the elaboration of a definite and reliable means of roentgen diagnosis of its functional and organic abnormalities with the methods at hand. Preëminent among those who made significant contributions to this phase of the work were Rieder, Haenisch, Schwarz, Stierlin, Groedel,[16,17] Case, George, Carman and Miller, Cole, and Brown and Sampson.

Most recent developments in methods of investigation are the combined method elaborated by Fischer, mentioned in the foregoing, and the studies of mucosal relief with which the names of Forssell, Berg, Knothe and Chaoul are prominently identified. This last mentioned method of diagnosis, when reduced to its essentials, rests on a study of the internal relief patterns of the mucosa of the colon after the opaque enema has been evacuated. In this connection it is worthy of note that Cole,[11] and undoubtedly others, were eliciting significant information by this method as early as 1915. Berg and his followers, however, should be credited with bringing this valuable method of study into the foreground of general attention, and with giving it intensive and critical consideration.

Most of the methods of investigation, the development of which I have thus briefly outlined, have been practical, and as such have been preserved for general use today. The use of the gases alone as contrast substances has been abandoned generally, because the contrast is not sharp enough, and the contours of the bowel are not made sufficiently distinct. Insufflation with air or some other gas may be used to provide rapid localization of a palpable abdominal mass, but this is accomplished by the contrast enema with the advantage of greater distinctness of outline. In special instances, when, as Cole and Einhorn suggested, for some reason the use of opaque salts may be inadvisable or contraindicated, simple insufflation of the bowel may serve a useful purpose. Such circumstances are encountered rarely.

Insufflation of the colon after waiting until a previously administered opaque meal has had sufficient time to be transported into its proximal segments, as used first by Hildebrand and Rumpel, later advocated by Laurell, may provide useful information about the cecal and proximal ascending segments of the colon, but in this and the more distal segments, including the hepatic flexure, the stool is already formed, and the procedure has little more to offer than simple insufflation.

Pneumoperitoneum has found but extremely limited application in the investigation of diseases and conditions in which the large intestine may be involved.

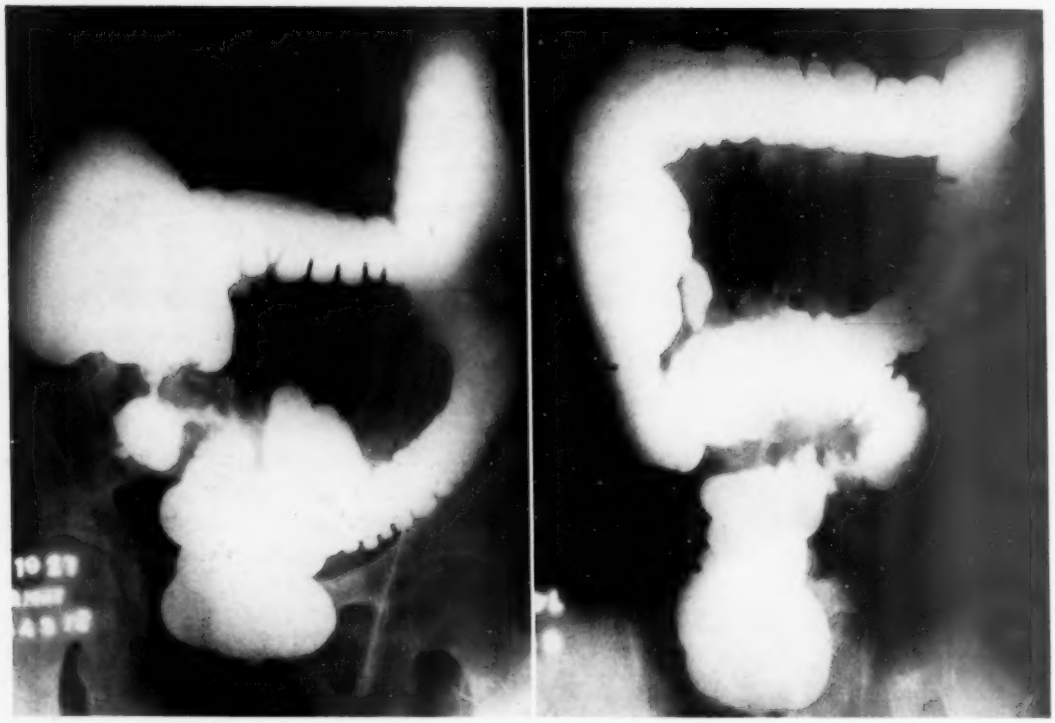
The current methods of visualizing the colon for diagnostic purposes are the contrast meal, the contrast enema, the study of the mucosal relief, and the double contrast enema. All except the contrast meal might as well be considered together as comprising a single method, rating the studies of mucosal relief and those with the use of the double contrast enema as complements to, and refinements of, the examination with the simple opaque enema.

Most of the early examinations of the large intestine were carried on with the contrast meal. It is still the cardinal procedure in use when objective evidence of the motor activity of the bowel is sought. Although it is in fact the most nearly physiologic of the roentgenologic methods of investigation, still it is somewhat unphysiologic, and this is well kept in mind in making determinations of aberrations from normal function. It seems to me that many of the

alleged roentgenologic signs of functional colonic disorder are intimately associated with the physical character of the contrast meal itself. There is no established manner of preparing the opaque meal. A great variety of mixtures is employed, but all of them contain a high concentration of the metallic salt in use. Compared with the specific gravity of the material which the colon is designed to contain, that of the ordinary opaque meal is surprisingly high. In addition, the fate of this ponderous mass of relatively inert material, under the dehydrating influence of the proximal portion of the colon, should be borne in mind. The patient's intake of fluid has been modified, if for no other reason than because he is having a roentgenologic examination. Under these circumstances physicians of the Section on Roentgenology of The Mayo Clinic are not inclined to regard the appearances assumed by the opaque meal, under the influence even of the normal motor activity of the colon, as entirely representative of the appearance an ordinary meal would assume, could it be adequately visualized. The functional activity of the colon, and of the intestinal tract in general, is so variably affected by such a variety of extraneous and uncontrollable influences, that roentgenologic judgments in this respect are given with extreme caution, and of necessity would be influenced and modified by clinical knowledge of the particular patient undergoing examination.

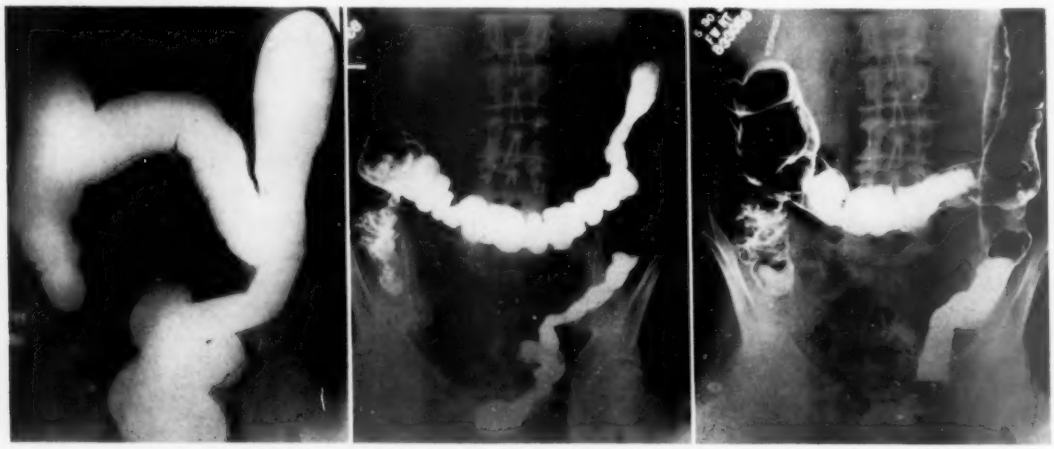
The opaque meal, applied to the investigation of organic disease of the colon, when used alone, becomes a source of error and confusion. If the efficiency of the roentgenologic method applied to the investigation of the large intestine is underestimated in some quarters, then I hold the placing of too much reliance on the contrast meal responsible. No other roentgenologic procedure entails such an abundance of illusory appearances. The procedure is cumbersome and time-consuming, inasmuch as repeated roentgenoscopic examinations are always required. A satisfactory survey of the entire colon at any given time is difficult to obtain even with the use of the double meal recommended by Fischer.[14] Obstruction when present in high degree is made manifest, but the accumulation of a mass of heavy, inert material above an obstructing or constricting process is studiously to be avoided. Phenomena of local or general hypermotility are generally considered as constant in the ulcerative diseases of the colon and are efficiently observed with this method of examination. But the type of evidence elicited is largely indirect, and hence of diminished diagnostic value when compared with the direct evidence securable by other methods. When rigidly controlled, however, as is the application of this method to the recognition of intestinal tuberculosis, the evidence supplied merits serious consideration.

Since all organic diseases of the colon produce change in the internal or external contours of its lumen, or both, those procedures which serve best to bring out the anatomic characteristics of the deformity are to be preferred. Roentgenoscopic observation of the contrast enema is the method of maximal efficiency for this purpose. For this reason it is considered the cardinal roentgenologic method in the investigation of all types of disease of the large intestine, malignant or benign. The advantages it offers seem obvious. The diagnostic elements which the roentgenologic method affords are not solely visual. The purely visual elements are reënforced with other features, especially those supplied by topical manipulation of diseased parts. With roentgenoscopic observation of the opaque enema, the entire organ can be viewed as a unit in its living state, or any part of it can be subjected to separate visual and manipulative scrutiny at any instant, from any desired angle. Exact information regarding mobility, flexibility, and the character and persistence of defects and irregularities in contour is instantly available. In most instances of organic disease it is possible to elaborate a pathognomonic roentgenologic syndrome from the



a *b*

Fig. 1. The opaque enema. Deforming lesions of the colon: *a*, carcinoma just below the ileocecal valve; *b*, diverticulitis of the sigmoid. Typical and pathognomonic roentgenologic appearances.



a *b* *c*

Fig. 2. Polypoid carcinoma of the cecum. *a*, opaque enema shows deformity of the cecum not characteristic of malignancy; *b*, after evacuation of the opaque enema; the mucosal relief is abnormal, but the nature of the lesion is not apparent; *c*, the double contrast method; the intraluminal character of the lesion is obvious.

data elicited from this, the fundamental phase of the roentgenologic examination alone (Fig. 1).

Roentgenoscopic observation of the opaque enema has been designated as the cardinal procedure because, from the diagnostic data it yields, the indications for extension of the examination to include other and more refined techniques are inferred (Fig. 2). Of these, the most commonly employed are roentgenography of the bowel distended with the opaque enema, and special examination of the mucosa and internal topography of the lumen of the colon, using roentgenoscopic and roentgenographic examination after the contrast enema has been evacuated, both before and after distention with air or some harmless gas. These are rated as auxiliary maneuvers complementary to but not superseding the cardinal procedure.

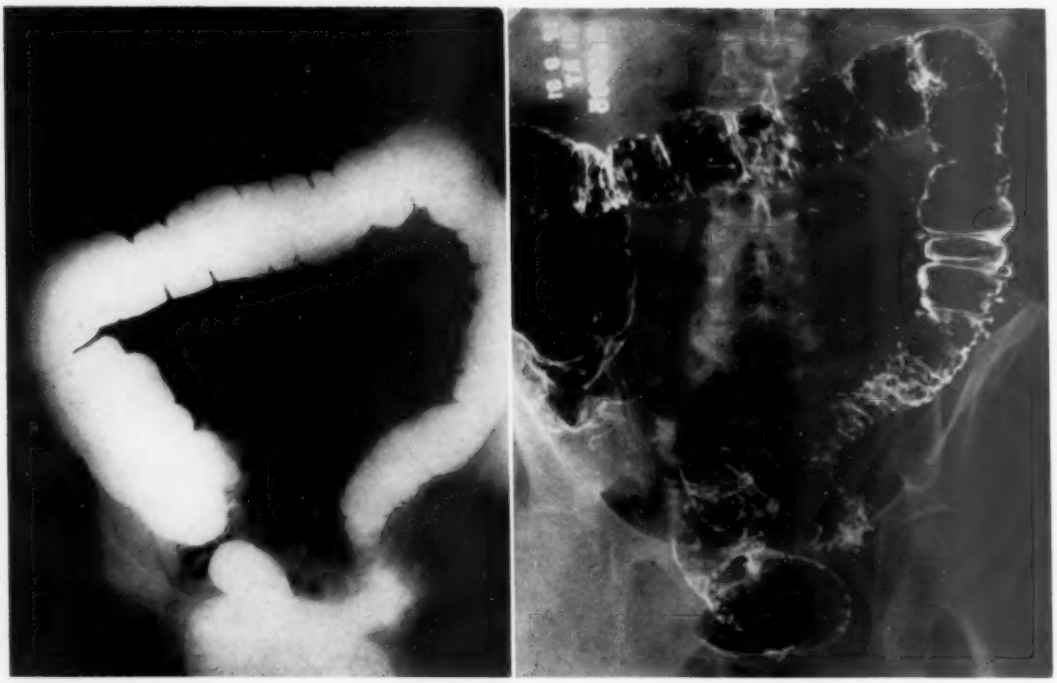
The mucosal surface of the gastrointestinal tract in general merits special attention, and even a special technique of investigation, principally because it is on this surface that the earliest and most conspicuous evidence of macroscopic pathologic change is found. Inspection of the mucosal relief, and the double contrast method, are procedures designed especially for the roentgenologic demonstration of changes in the mucosa and internal topography of the colon for which purpose older methods were deficient. Properly applied they make an invaluable contribution to increased accuracy and general efficiency in the diagnosis of organic disease of the colon.

The double contrast method deserves special comment. When successfully executed it affords an opportunity for estimating the integrity of the interior of the colonic lumen attainable by no other means except direct inspection. Providing what is essentially a transparent medium, its greatest advantage is its adaptability for demonstrating with precision and accuracy those obscure, small, nondeforming lesions, the polypoid lesions, which are otherwise visualized with greatest difficulty, if at all (Fig. 3).

A further point of superiority is the increased distinctness with which significant anatomic characteristics of lesions are depicted (Fig. 4). With the opaque enema a diseased segment of colon is often more or less adequately visualized and manipulated roentgenoscopically, but despite all efforts, the diseased segment may be persistently obscured on the roentgenogram by overlying loops filled with the densely opaque contrast material. This difficulty is obviated to a great extent with the use of the transparent, double contrast technique.

Fig. 3. Double contrast method. Diffuse polypoidosis. The small polypoid lesions are visualized with a distinctness no other method could offer.

As a matter of principle, the complete roentgenologic examination will include all methods necessary for rendition of a complete and precise diagnosis. No one method is capable of accomplishing this task in every case. Methods, however, do not make diagnoses. The complete roentgenologic examination is largely and essentially a special method of eliciting those features of disease which are apparent to the eye and hand on direct examination of diseased tissue. A most intimate relationship exists, therefore, between the anatomic and roentgenologic methods of diagnosis. Diagnostic efficiency is fundamentally and intimately associated with the individual ex-



a *b*

Fig. 4. Diverticulitis of the sigmoid. Diverticulosis of the descending colon. *a*, opaque enema; *b*, the double contrast method. The anatomic characteristics of the pathologic process are depicted with greater precision.

aminer's familiarity with the gross pathologic features of lesions encountered, and with the facility with which he correlates roentgenologic with pathologic data. In the diagnosis of organic disease, the value of any given method, or combination of methods, is measured entirely by the clarity and distinctness with which it reveals pertinent data translatable into terms of pathologic anatomy.

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REACTION OF TRANSPLANTABLE MOUSE SARCOMA NO. 180 TO RADIATIONS OF DIFFERENT WAVE LENGTHS

(200 KV. ROENTGEN RAYS AND GAMMA RAYS)*

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Introduction

SINCE the discovery of the x-ray in 1895 and radium in 1898, there have been many investigations into the biological properties of roentgen rays and gamma rays. The use of different biological materials combined with various qualities of radiation, intensity of radiation and time during which the full dose is administered has led to varying results and, therefore, much controversy. At the recent Symposium on "The relative effects produced by 200 kv. roentgen rays, 700 kv. roentgen rays, and gamma rays" members of the Memorial Hospital staff[1] presented papers and discussed the quantitative relationship between the biological action of these rays.

The work here reported was planned to determine the relative effectiveness of 200 kv. roentgen rays and gamma rays as lethal agents, using a transplantable mammalian tumor as the test object.

Materials and Methods

The mouse sarcoma No. 180 was selected on account of its regularity and high percentage of successful takes. During the past two years we have made nearly 1,000 normal tumor implantations and found that in the majority of the series the tumor takes were 100 per cent and seldom below 90 per cent, the average takes being 99 per cent. The transplants ultimately regressed in about 4 per cent of the positive growths. This sarcoma grew progressively and rapidly. Many of them developed pressure necrosis at the subcutaneous parts of the tumors as early as the third week, and subsequently caused the deaths of the animals from toxemia, septicemia and nutritional failure.

The subcutaneous inoculations of the tumor fragments (about 6 mg. pieces) into healthy young adult white mice were done by the trocar method and the tumors were generally allowed to grow for a period of six weeks.

Each set of experiments included the inoculation of animals with untreated tumor tissue immediately after removal from the tumor-bearing animal.

It is essential to know the relation of mouse sarcoma No. 180 to physical and chemical environments which may have a bearing upon the present investigation.

Effect of Multiple Implantation upon the Growth of Mouse Sarcoma No. 180

Transplantation experiments with mammalian neoplasms[2] indicate that re-implantation with similar tumor tissue within a short time may affect the takes of primary or secondary implants, or both. The degree of the concomitant immunity, however, varies with different tumor parenchymata.

We carried out several preliminary experiments to determine the suitability of a multiple implantation of mouse sarcoma No. 180 because should the tumor show a dependable growth in mice the expense of investigation might be greatly reduced. The results obtained from the single and multiple inoculations of tumor tissues showed that the percentage of tumor takes and the rate of tumor growth were not affected by a second, third or even a fourth

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implant. However, throughout the present work we adopted most often the double implantation technique (single grafts at the right and left axilla), because the presence of a greater number of implanted tumors reduced the duration of life of these tumor-bearing animals.

Effect of Desiccation upon the Growth of Mouse Sarcoma No. 180

It is a well-established fact that the transplantable mammalian neoplasms lose their viability by complete desiccation. The extent of the injurious action of partial dehydration, however, is not well understood. For that reason we made the following experiments.

Fragments of fresh tumor tissue, each weighing about 6 mg., were subjected to dehydration at room temperature in a desiccator containing $CaCl_2$-NaOH for variable periods of time. At the end of the experimental time the loss of water content was determined and immediately the tumor fragments were treated with a Locke-Ringer solution at pH 7.0 and allowed to stand for about thirty minutes in the refrigerator. The softened tumor tissues were inoculated into mice in the usual way.

It was found that at the end of thirty minutes in a desiccator the fresh tumor tissue lost about 33 per cent of its original water content, after one hour, about 58 per cent, after two hours, about 90 per cent, and after three hours, about 95 per cent. These figures are the average of four sets of experiments.

The normal transmissibility of mouse sarcoma No. 180 was not changed by the loss of from 33 to 58 per cent of its original water content. When the fragments lost 90 per cent of the original water content only 40 per cent of fragments remained viable and the growth capacity of the tumor fragments was completely destroyed by loss of 95 per cent of the original water content.

The water content of the two to three weeks old mouse sarcoma No. 180 (healthy, non-necrotic area) was found to be about 84 per cent.

The Influence of Hydrogen Ion Concentration upon the Viability of Mouse Sarcoma No. 180

Our previous studies with the Flexner-Jobling rat carcinoma,[3] the Rous chicken sarcoma,[4] and the Sugiura rat sarcoma[5] indicated that these tumors showed marked differences in their reaction to different hydrogen ion concentrations. Knowledge of the relationship between pH and viability of mouse sarcoma No. 180 is desirable in connection with the present study.

Two sets of solutions were used for regulating hydrogen ion concentration. One was the standard pH solutions recommended by Clark, and the other a Locke-Ringer solution* previously adjusted colorimetrically to the required pH values with 0.10N and 0.01N solutions of HCl and NaOH.

Ten or more small pieces of tumor tissue, each weighing about 6 mg., were placed in a 25 c.c. portion of solution of definite hydrogen ion concentration and salt content. The solutions had previously been sterilized in a steam autoclave at 15 pounds pressure for fifteen minutes. The flasks containing the solutions and tumor fragments were allowed to remain for twenty-four hours in the refrigerator at a temperature of 4–5° C. At the end of this period, the tumor fragments were transplanted into animals. The results are presented in Table 1.

It is evident that the growth capacity of the mouse sarcoma No. 180 was completely destroyed by immersing in a Clark's buffer mixture solution or in a Locke-Ringer solution at pH 4.0 or pH 10.0. At pH 5.0, 69 per cent inhibition and at pH 9.0, 61 per cent inhibition occurred. On the other hand, the tumor fragments which had been immersed in a solution at pH 6.0, 7.0 or 8.0 for twenty-four hours grew normally when implanted into mice.

*A solution contained 0.15 moles NaCl 0.003 moles KCL and 0.003 moles $CaCl_2$ per liter.

Action of Roentgen Rays on the Growth of Mouse Sarcoma No. 180

As a preliminary study, we have determined the extent of the injurious action of unfiltered roentgen rays on the proliferating capacity of sarcoma cells *in vitro*.

In order to avoid uncertainties due to secondary radiations and the loss of tissue water a special cellophane chamber was constructed. One layer of very thin cellophane (0.001 mm.) was stretched over an ordinary wooden embroidery hoop with a diameter of 9.5 cm. On this was placed a piece of filter paper slightly moistened with a Locke-Ringer solution at pH 7.0. Fragments of a fresh tumor tissue, each weighing about 6 mg., and measuring about 2 mm. in thickness, were then arranged in rows on the paper as shown in Figure 1. A second embroidery hoop with a diameter of 12 cm. with one sheet of cellophane stretched across was then placed over it, to reduce the normal evaporation of water and bacterial contamination. Aseptic precautions were taken in the preparation for the irradiation experiments.

Tumor materials to be used for the irradiation experiments were selected among rapidly growing tumors which had not ulcerated. They were from two to three weeks old.

The irradiation of the tumor fragments

TABLE I

RESULTS OF TRANSPLANTING MOUSE SARCOMA NO. 180 AFTER IMMERSING IN VARIOUS PH SOLUTIONS AT 4–5°C.

Exp. Number	No. of Tumor Transplants Used	Name of Solution	pH	Growth of Transplants (per cent)	Remarks
1	20	Controls	—	100	Rapid growth.
	20	Clark	4.13	0	No growth.
	20	Clark	5.0	40	12 tumors did not grow; others grew rapidly.
	20	Clark	5.8	100	Rapid growth.
	20	Clark	8.9	20	16 tumors did not grow; 4 tumors no growth for 2 weeks, then normal growth.
	20	Clark	10.1	0	No growth.
2	12	Controls	—	100	1 tumor grew slowly; others grew rapidly.
	12	Clark	4.13	0	No growth.
	12	Clark	5.0	33	8 tumors did not grow; others grew normally.
	12	Clark	5.8	100	2 tumors grew slowly; others grew rapidly.
	12	Clark	7.0	100	Rapid growth.
	12	Clark	7.9	100	2 tumors grew slowly; others grew rapidly.
	12	Clark	8.9	58	5 tumors did not grow; others grew normally.
	12	Clark	10.1	0	No growth.
3	16	Controls	—	100	2 tumors grew very slowly; others grew normally.
	16	L–R	4.0	0	No growth.
	16	L–R	5.0	19	13 tumors did not grow; others grew normally.
	16	L–R	9.0	38	10 tumors did not grow; others grew normally.
	16	L–R	10.0	0	No growth.

was begun within 1.5 hours after removal of the tumor from the animal, unless otherwise stated.

In the present experiments the tumor fragments were subjected to the radiation from a standard water-cooled Coolidge roentgen tube under the following conditions: 200 kv., 30 ma., no filter, and 35 cm. distance from the target. At this point, the intensity of the beam measured in air was found to be approximately 243 roentgens per minute. The temperature of the roentgen-ray chamber during the irradiation did not exceed 22° C.

At the end of definite intervals of time the irradiated tumor fragments were removed from the cellophane moist chamber and immediately implanted into animals in the usual way, or they were transferred temporarily to a small Petri dish containing a sheet of moist filter paper and allowed to remain in the refrigerator until ready for implantation. At the same time pieces of treated tumor tissues were fixed in formalin for histological examination.

The tumor takes and their subsequent rate of growth are influenced by many factors. It is essential, therefore, that all the experiments be carried out as uniformly as possible, and that proper controls be made.

The development of the tumors in the animals was recorded graphically by measuring them every week by means of calipers. Some irradiated transplants proliferated in the animals for several days or showed the original, palpable implants for about two weeks, but if they were completely absorbed within three weeks they were considered as negative transplants. On the other hand, tumors growing over three weeks in the animals are considered as positive transplants. In general, the tumors were allowed to grow for a period of six weeks and the negative growths were finally controlled by autopsy.

The results obtained from the unfiltered roentgen rays are presented in Table II. In the last column we have given a brief account of the irradiated and non-irradiated tumors because there was a subnormal rate of growth of malignant tumors after sublethal irradiation. The data are arranged according to the increasing duration of tissue exposure.

It is clear that the transplantable mouse sarcoma is uniformly sensitive to unfiltered roentgen rays (200 kv., 30 ma.). The tumor fragments exposed for from one to five minutes to the radiation remained viable, the growths being practically the same as in the controls. As irradiation continues the tumor cells die quickly, though some can resist the enormous dose of 2,200 r (Fig. 2). However, the viability of the transplants was completely destroyed by the radiation in ten minutes of exposure. Under these conditions the tumor tissues received a total of about 2,400 r.

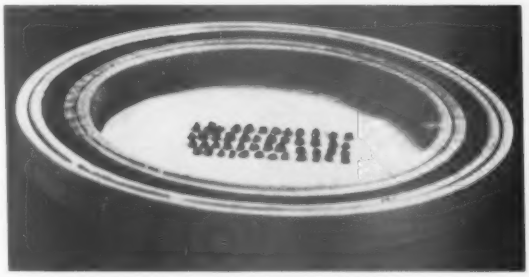

FIG. 1. Cellophane moist chamber for exposing tumor tissues to roentgen and gamma rays. The fragments in this photograph are those of a transplantable mouse melanoma.

It may be noted that of the 55 tumors which survived the radiation, the times of exposure being from six to nine minutes, 42, or 76 per cent, grew at much below normal rate and only 13 tumors showed rapid growth. In some cases the retarded tumor growth continued for several weeks, and the tumor subsequently underwent complete regression, while in the others retardation lasted only from two to three weeks and growth was normal thereafter.

Experiments with Filtered Roentgen Rays

Experiments duplicating those with unfiltered radiation were made with filtered radiation. The fragments of fresh mouse sarcoma No. 180 were irradiated under the

TABLE II

RESULTS OF TRANSPLANTING MOUSE SARCOMA NO. 180 AFTER EXPOSURE TO UNFILTERED ROENTGEN RAYS (200 KV., 30 MA.)

Exp. Number	No. of Tumor Transplants Used	Duration of Exposure (minutes)	Growth of Transplants (per cent)	Remarks
1	20	Controls	100	17 tumors grew rapidly; others grew slowly.
	19	1	100	Rapid growth.
	20	3	100	12 tumors grew rapidly; others grew slowly.
	20	6	80	4 tumors did not grow; 10 tumors grew slowly; others grew rapidly.
2	15	Controls	100	11 tumors grew rapidly; others grew slowly.
	24	5	92	2 tumors did not grow; with 2 tumors, no growth for 4 weeks, then slow growth; others grew rapidly.
	24	10	0	No growth.
3	20	Controls	100	Rapid growth.
	19	6	79	4 tumors did not grow; 8 grew slowly; others grew normally.
	20	7	30	14 tumors did not grow; 2 grew slowly others grew very slowly.
	20	8	20	16 tumors did not grow; 2 grew slowly; others grew very slowly.
	20	9	10	18 tumors did not grow; others grew slowly.
	20	10	0	No growth.
4	10	Controls	100	Rapid growth.
	10	7	30	7 tumors did not grow; others grew slowly.
	10	12	0	No growth.
	10	17	0	No growth.
5	20	Controls	100	Rapid growth.
	20	8	20	16 tumors did not grow; others grew slowly.
	20	9	10	18 tumors did not grow; 1 tumor grew slowly; other grew very slowly.
	20	10	0	No growth.
6	10	Controls	100	8 tumors grew rapidly; 2 tumors regressed after growing for 4 weeks.
	10	8	10	9 tumors did not grow; 1 tumor grew very slowly for 4 weeks, then regressed.
	10	9	0	No growth.
	10	10	0	No growth.
	10	11	0	No growth.
7	10	Controls	100	9 tumors grew rapidly; 1 tumor grew slowly.
	10	8	20	8 tumors did not grow; others grew slowly.
	9	12	0	No growth.
	10	16	0	No growth.
	10	20	0	No growth.

following conditions: 200 kv., 30 ma., 0.5 mm. copper and 1.6 mm. aluminum filters, and 50 cm. distance. Under these conditions the tumor tissues received 44.7 r per minute. The half-value thickness for the quality of radiation used was 0.9 mm. of copper. The results obtained from the filtered roentgen rays are summarized in Table III and shown also in Figure 3. In the figure the dosage is given in roentgens.

These results show that sixty-three minutes' exposure (about 2,800 r) of the tumor fragments to filtered radiation prevented their growth completely when inoculated into animals. If the exposure was not too long, so that a dose of about 2,600 r or less was used, there was a delayed onset of growth and marked inhibition and retardation of the subsequent growth. A graphic illustration of a typical example of the progress of irradiated and non-irradiated tumors may show this point more clearly (Fig. 4). The present results are in accord with the findings of Wood[6] who, working with mouse sarcoma No. 180, found that

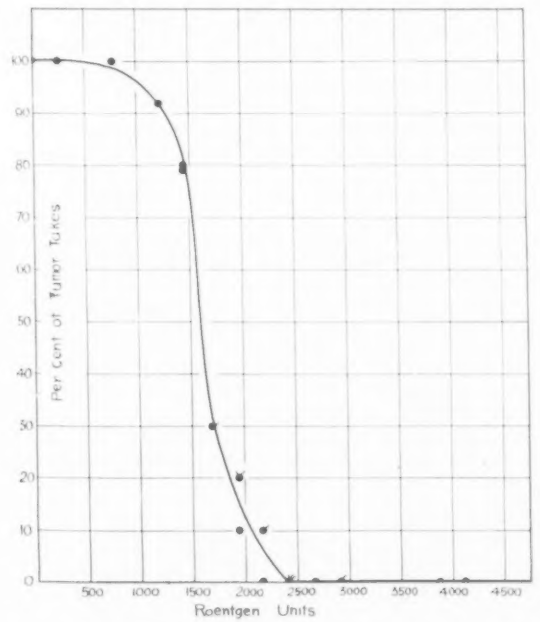

Fig. 2. Survival curve of mouse sarcoma No. 180 exposed to 200 kv. roentgen rays, no filter, intensity = 243 r/min. Each line surrounding a point indicates additional identical point.

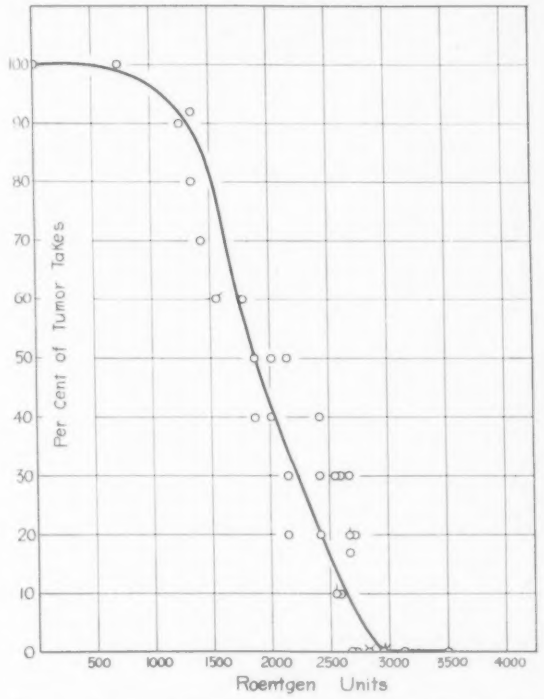

Fig. 3. Survival curve of mouse sarcoma No. 180 exposed to 200 kv. roentgen rays, filter 0.5 mm. Cu + 1.6 mm. Al, intensity = 44.7 r/min. Each line surrounding a point indicates an additional identical point.

no takes occur after the tumor particles have received a dose of about 2,700 r. They also are in agreement with the findings of Packard[7] who has pointed out that the full lethal dose of mouse sarcoma No. 180 is about 2,750 r. In his experiments the tumor particles were irradiated under the following conditions: 550 kv., 3.2 ma., 6 mm. steel filter and 40 cm. distance.

It is interesting to note that of the 83 tumors which survived the irradiation, the times of exposure being from forty to sixty-one minutes, 60, or 72 per cent, grew at much below the normal rate and only 23 tumors showed rapid growth. In some cases the growth of the tumor was retarded for several weeks. This may have been due to injury of the cell nucleus which was caused by irradiation and which hindered the normal process of cell division.

In order to investigate the possibility that irradiation caused changes in the

TABLE III

RESULTS OF TRANSPLANTING MOUSE SARCOMA NO. 180 AFTER EXPOSURE TO FILTERED ROENTGEN RAYS (200 KV., 30 MA., 0.5 MM. CU + 1.6 MM. AL FILTER)

Exp. Number	No. of Tumor Transplants Used	Duration of Exposure (minutes)	Growth of Transplants (per cent)	Remarks
1	20	Controls	100	2 tumors grew slowly; others grew rapidly.
	20	16	100	Rapid growth.
2	20	Controls	100	2 tumors grew slowly; others grew rapidly.
	20	28	90	2 tumors did not grow; 6 grew slowly; others grew rapidly.
	20	32	70	6 tumors did not grow; 6 grew very slowly; others grew rapidly.
	20	35	60	8 tumors did not grow; 8 grew very slowly; others grew rapidly.
3	10	Controls	100	Rapid growth.
	10	30	80	2 tumors did not grow; 3 regressed after growing slowly for 5–7 weeks; others grew rapidly.
	10	35	60	4 tumors did not grow; others grew rapidly.
	10	40	60	4 tumors did not grow; 2 regressed after growing very slowly for 5 weeks; others grew rapidly.
4	12	Controls	100	1 tumor grew slowly; others grew rapidly.
	12	30	92	1 tumor did not grow; 2 grew slowly; others grew rapidly.
	10	45	50	5 tumors did not grow; 3 grew slowly; others grew rapidly.
	12	60	17	10 tumors did not grow; others grew slowly.
5	10	Controls	90	1 tumor did not grow; 5 grew slowly; others grew rapidly.
	10	42	50	5 tumors did not grow; 3 grew slowly; others grew rapidly.
	10	45	40	6 tumors did not grow; 2 grew slowly; others grew rapidly.
	10	48	30	7 tumors did not grow; 2 grew slowly; other grew rapidly.
6	19	Controls	100	2 tumors regressed after growing for 5–6 weeks; others grew rapidly.
	20	42	40	12 tumors did not grow; 4 regressed after growing very slowly for 4–5 weeks; 2 grew slowly; others grew rapidly.
	20	48	20	16 tumors did not grow; others grew very slowly for 2 weeks, normal thereafter.
	20	54	20	16 tumors did not grow; others grew very slowly for 3 weeks, normal thereafter.
	20	60	0	No growth.
7	10	Controls	100	Rapid growth.

TABLE III (*Continued*)

Exp. Number	No. of Tumor Transplants Used	Duration of Exposure (minutes)	Growth of Transplants (per cent)	Remarks
	10	48	50	5 tumors did not grow; others grew rapidly.
	10	54	40	6 tumors did not grow; 1 grew very slowly; 3 grew slowly for 2 weeks, normal thereafter.
	10	60	30	7 tumors did not grow; others grew slowly.
	10	66	0	No growth.
8	10	Controls	100	1 tumor grew slowly; others grew rapidly.
	10	54	30	7 tumors did not grow; others grew slowly.
	10	60	20	8 tumors did not grow; 1 grew very slowly; others grew rapidly.
	10	66	0	No growth.
	10	70	0	No growth.
9	20	Controls	100	Rapid growth.
	20	57	10	18 tumors did not grow; others grew very slowly.
	20	63	0	No growth.
10	10	Controls	90	1 tumor did not grow; others grew rapidly.
	10	57	10	9 tumors did not grow; others grew slowly.
	10	63	0	No growth.
11	20	Controls	100	Rapid growth.
	20	57	30	14 tumors did not grow; others grew slowly.
	20	60	20	16 tumors did not grow; others grew very slowly.
	20	63	0	No growth.
	20	66	0	No growth.
12	20	Controls	100	Rapid growth.
	20	58	30	14 tumors did not grow; with 4, no growth for 2–3 weeks, then slow growth; others grew rapidly.
	20	61	20	16 tumors did not grow; with 2 no growth for 3 weeks, normal thereafter, others grew normally.
13	20	Controls	100	Rapid growth.
	20	58	10	18 tumors did not grow; others grew slowly.
	20	61	0	No growth.

Locke-Ringer solution which might produce secondary changes in the tumor, we exposed a Locke-Ringer solution to roentgen rays under identical conditions of irradiation. Then the tumor fragments were placed in this solution for one hour before implantation into healthy mice. It was found that the irradiated Locke-Ringer solution did not affect the growth energy of the tumor.

It may be of interest to mention that under the stated conditions of irradiation, both filtered and unfiltered roentgen rays have not induced any stimulating influence

upon mouse sarcoma No. 180.

Histological examinations of a number of the tumor tissues after exposure to filtered roentgen rays were made. The general structure of non-irradiated tissue showed a very cellular, small spindle and polyhedral cell sarcoma, in areas degenerated and necrotic. The sections of irradiated tissues showed no definite changes, the tumor cells appearing to be viable. filtered roentgen rays for forty to sixty minutes. At the end of the sixth day after implantation some of the animals were killed with ether. At necropsy the control tumors on the right axilla were considerably larger due to rapid cell division. The tumors were firmly fixed to the areolar tissue. There was a marked hyperemia of the lateral thoracic artery. The tumor tissues on the left axilla which had been ir-

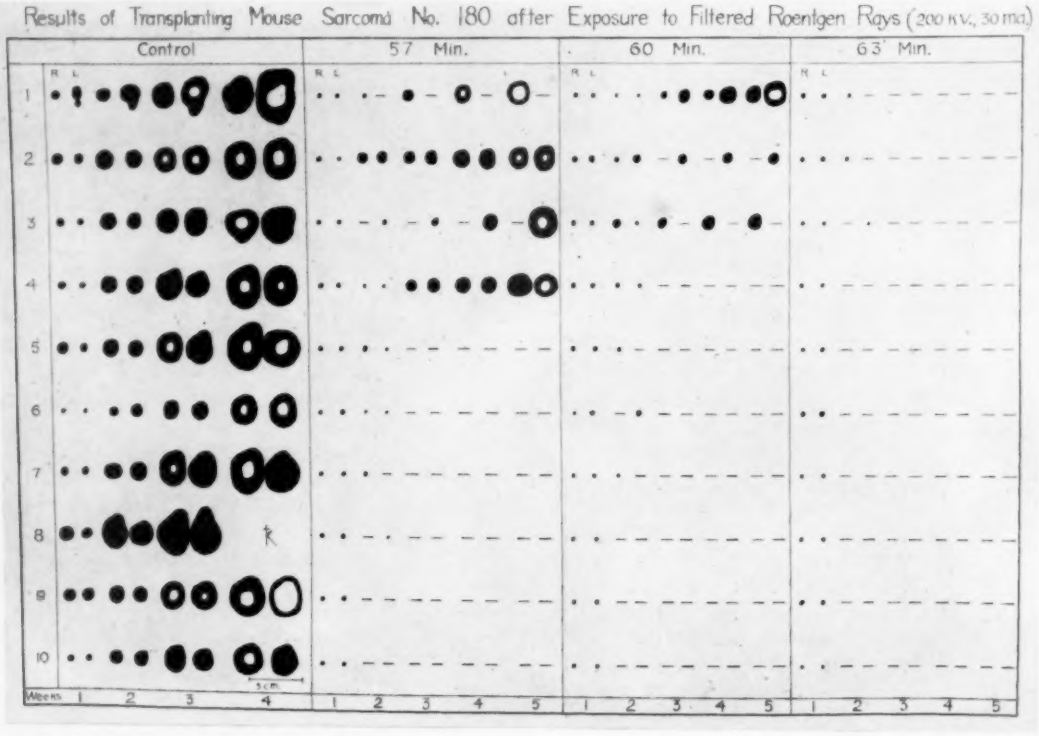

FIG. 4. Experiment 11, Table III. Sixty-three minutes' exposure (about 2,800 r) of the tumor fragments to filtered radiation prevented their growth completely when inoculated into animals. If a dose of about 2,600 r (60 min.) or about 2,500 r (57 min.) was used, there was a delayed onset of growth and marked inhibition and retardation of the subsequent growth. Unshaded areas in the tumors represent pressure necrosis.

Yet the growth energy of the transplants which had received 1,500 r or more was distinctly reduced.

There was an interesting correlation between the tumor growth and hypermia. Healthy young adult mice were inoculated in the region of the right axilla with a piece of non-irradiated mouse sarcoma and in the region of the left axilla with a piece of tumor tissue which had been exposed to radiated for forty minutes (1,788 r) were slightly larger than the original size. There was a moderate hyperemia of the lateral thoracic artery. On the other hand, the tumor tissues irradiated for sixty minutes (2,682 r) remained the size of the original implants. The blood vessels leading to the implants were normal, very fine as though there was no active tumor.

In the course of the investigation we

have determined the viability of tumors greatly stunted by previous irradiation. It was found that not only the rate of growth but also the number of tumor takes was reduced. Whether or not this retardation of growth energy could be restored by a successive transplantation generation is uncertain. Further experiments are required to answer these questions.

Experiments with Gamma Rays

To determine the effect of much shorter wave length radiation we have used highly filtered gamma rays from 4 grams of radium element. The construction of the radium element pack has been fully described by Failla.[8]

Since the main purpose of the experiment was to compare the effect produced by gamma rays with that of highly filtered roentgen rays, the two sets of experiments were arranged as nearly identical as practical and whenever possible the tumor materials used in both cases were taken from the same animals.

Fig. 5. Four gram radium element pack. Showing the position of a cellophane moist chamber containing tumor material.

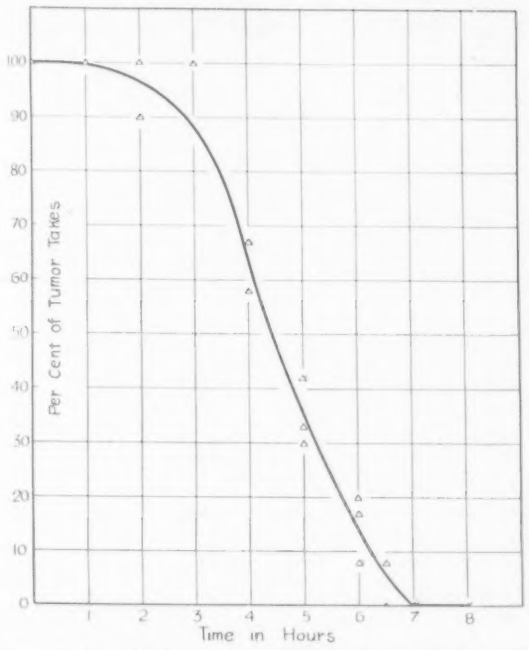

Fig. 6. Survival curve of mouse sarcoma No. 180 exposed to 4 grams radium element, filter equivalent to 2.0 mm. Pb+2.5 mm. celluloid. Each line surrounding a point indicates an additional identical point.

In the present investigation the tumor fragments in the cellophane moist chamber (Fig. 5) were irradiated under the following conditions: 4 grams of radium, primary filter equivalent to 2.0 mm. lead, secondary filter 2.5 mm. celluloid, distance 6 cm. The temperatures of the 4 gram radium element pack room during the irradiation were from 14.5 to 17° C. Whenever necessary a few drops of sterile Locke-Ringer's solution at pH 7.0 were added to the cellophane chamber in order to maintain the filter paper at the proper degree of wetness. The results obtained with gamma rays are presented in Table IV. In Figure 6 the extent of tumor takes in percentage is plotted against time of treatment in hours.

As may be seen from the data in Figure 6, the transplantability of mouse sarcoma No. 180 was not altered appreciably by an exposure of from one to three hours to the gamma rays from 4 grams of radium under the conditions of the experiment. At four hours' exposure partial inhibition and

TABLE IV

RESULTS OF TRANSPLANTING MOUSE SARCOMA NO. 180 AFTER EXPOSURE TO GAMMA RAYS (4 GM. RADIUM ELEMENT, FILTER EQUIVALENT TO 2.0 MM. PB, AND 2.5 MM. CELLULOID FILTER)

Exp. Number	No. of Tumor Transplants Used	Duration of Exposure (hours)	Growth of Transplants (per cent)	Remarks
1	18	Controls	100	2 tumors grew slowly; others grew rapidly.
	18	1.0	100	Rapid growth.
	20	2.0	100	3 tumors grew slowly; others grew rapidly.
2	10	Controls	90	1 tumor did not grow; others grew rapidly.
	10	2.0	90	1 tumor did not grow; others grew rapidly.
3	24	Controls	100	Rapid growth.
	24	3.0	100	Rapid growth.
	24	4.0	67	8 tumors did not grow; others grew slightly below normal.
	24	5.0	33	16 tumors did not grow; others grew slowly.
4	24	Controls	96	1 tumor did not grow; 2 grew slowly; others grew rapidly.
	24	4.0	58	10 tumors did not grow; others grew slowly.
	24	6.0	8	22 tumors did not grow; others grew very slowly.
	24	6.5	0	No growth.
	24	7.0	0	No growth.
5	24	Controls	100	Rapid growth.
	24	5.0	42	14 tumors did not grow: 8 grew slowly; others grew very slowly.
	24	6.0	17	20 tumors did not grow; 2 grew slowly: others grew very slowly.
	24	6.5	8	22 tumors did not grow; others grew very slowly.
6	20	Controls	100	Rapid growth.
	20	5.0	30	14 tumors did not grow; others grew slowly.
	20	6.0	20	16 tumors did not grow; others grew very slowly.
	20	7.0	0	No growth.
7	22	Controls	100	Rapid growth.
	24	5.0	42	14 tumors did not grow; 2 grew slowly; others grew very slowly.
	24	6.0	8	22 tumors did not grow; others grew slowly.
	22	7.0	0	No growth.
	24	8.0	0	No growth.
8	20	Controls	100	3 tumors grew slowly; others grew rapidly.
	20	8.0	0	No growth.

slightly delayed growth were observed. Marked inhibition and retardation of growth was caused after from five to six hours' exposure. The viability of the tumor was completely destroyed by seven hours' exposure.

As in the case of roentgen irradiation, of the 78 tumors which survived the gamma irradiation, the times of exposure being from 4 to 6.5 hours, 60, or 77 per cent, grew at much below the normal rate and only 18 tumors showed rapid growth. In some cases the retardation of tumor growth continued for several weeks, and the tumor subsequently underwent complete regression, while in the others retardation lasted only from two to three weeks and growth was normal thereafter.

The Influence of Time Factor in Irradiation of Mouse Sarcoma No. 180

What rôle the time factor will play in irradiation has been extensively reviewed in a recent article by Pack and Quimby.[9] It shows that some authors claim that the alterations in the factors of time and intensity have no significance in the application of a given dose, while others claim greater biological effects with less intensity and longer duration of irradiation, while still others claim greater biological effects with higher intensity and shorter duration of irradiation.

In the following experiments we sought to determine whether the time factor has any significance in the present study. The output of the roentgen machine was adjusted so that the ratio of time was approximately 1 to 5. For the lower intensity, the tumor fragments were irradiated under the following conditions: 165 kv., 30 ma., 1.7 mm. copper and 0.4 mm. aluminum filters, and 50 cm. distance. Under these conditions the tumor tissues received 9.5 r per minute. For the higher intensity, the setting was the same as that of the preceding experiments. The tumor materials were taken from the same animals and the fragments were exposed to the higher and lower intensities on the same day. The respective exposure times for the fragments were 3, 3.75, 4.5, 5.25, and 6 hours for the lower intensity and 30, 45 and 60 minutes for the higher. The data obtained are given in Table v. The values obtained from the higher intensity were also included in the curve given in Figure 7.

From this curve, showing the results obtained with radiation of different intensities, it will be seen that the percentages of

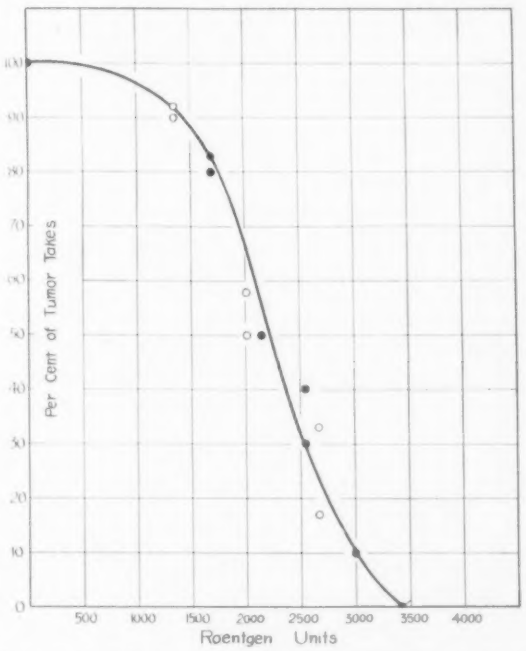

Fig. 7. Survival curve of mouse sarcoma No. 180 exposed to radiation of different intensities. ● = tumor fragments exposed to 165 kv. roentgen rays, filter 1.7 mm. Cu + 0.4 mm. Al, intensity = 9.5 r/min.
○ = tumor fragments exposed to 200 kv. roentgen rays, filter 0.5 mm. Cu + 1.6 mm. Al, intensity = 44.7 r/min.

tumor takes which follow exposure to radiation of lower intensity and longer duration were nearly the same as those obtained from exposure to radiation of higher intensity and shorter duration when the total output in roentgens was the same (ratio of time 1:5). Accordingly under these conditions the Bunsen-Roscoe Law is applicable.

TABLE V

RESULTS OF TRANSPLANTING MOUSE SARCOMA NO. 180 AFTER EXPOSURE TO FILTERED ROENTGEN RAYS (165 KV., 30 MA., 1.7 MM. CU+0.4 MM. AL FILTER)

Duration of Exposure		r	Growth of Transplants (per cent)	
High Intensity (minutes)	Low Intensity (hours)			
0		0	100	100
	0	0	100	100
30		1341	92	90
	3.0	1710	83	80
45		2012	50	58
	3.75	2138		50
	4.5	2565	40	30
60		2682	17	33
	5.25	2992		10
	6.0	3420	0	0

Discussion

The main purpose of the study was to compare the lethal effect produced by gamma rays on a transplantable mammalian tumor with that produced by roentgen rays at 200 kv. From the experimental data of Failla,[1] it is now possible to calculate the gamma-ray emission of the radium source in terms of "equivalent" roentgens per minute, the equivalence being based on the relative effectiveness of roentgen rays and gamma rays in producing a given biological effect, in this case the killing of tumor cells irradiated *in vitro*.

TABLE VI

Per cent of Tumor Takes	200 kv. X-Rays (roentgens)	Gamma Rays (minutes)	Ratio Equivalent r/min.
80	1500	210	7.1
70	1625	228	7.1
60	1750	246	7.1
50	1875	264	7.1
40	2050	288	7.1
30	2250	312	7.2
20	2450	342	7.2
10	2650	375	7.1
Average (equivalent roentgens per minute)			7.1

From the data given in Figures 3 and 6, Table VI was prepared. In Table VI column 2 are given the doses of filtered roentgen rays expressed in roentgens for different percentage of tumor takes. In column 3 are given the corresponding exposures to the radium pack expressed in minutes. Dividing the values in column 2 respectively by those in column 3 we obtain the ratios of column 4, which represent the "equivalent" roentgens per minute of the radium pack at the 6 cm. distance. It will be noted that these ratios differ very little throughout the range. This indicates that the *nature* of the effect produced by hard roentgen rays and gamma rays on mouse sarcoma No. 180 irradiated *in vitro* is essentially the same. But our experiments in themselves are not sufficient to determine the relative effectiveness of the two qualities of radiation.

We can, however, compare our results with those obtained by other experimenters at the Memorial Hospital who have used the two sources of radiation under the same conditions.[1] The results of these experiments have been summarized by Failla in Table I of Part VII of the Symposium. Our ratios of Table VI are directly comparable with those given by Failla. The radiation emission of the radium pack at 6 cm. determined with a spherical, thin-walled, celluloid ionization chamber, is 9.5 "equivalent" roentgens per minute, as compared to 7.1 for our experiments. The corresponding values obtained by biological experiments using wheat seedlings, *Drosophila* eggs and mouse tails are 11.4, 15 and 9 "equivalent" roentgens per minute respectively. It will be seen, therefore, that there is no very close agreement among the results of these physical and biological determinations. The difference in the results indicates a difference in the relative biological effectiveness of roentgen rays and gamma rays. But since biological experiments of this sort are subject to experimental errors of considerable magnitude, it is not possible at present to state that the difference is significant.

Summary

1. The effect of 200 kv. roentgen rays and gamma rays from 4 grams of radium, on mouse sarcoma No. 180 has been studied.

2. The viability of the mouse sarcoma was completely destroyed by ten minutes' exposure to unfiltered roentgen rays, a dose of about 2,400 roentgens.

3. The viability of the mouse sarcoma was totally inhibited by sixty-three minutes' exposure to the filtered roentgen rays, a dose of about 2,800 roentgens.

4. The viability of the mouse sarcoma was completely destroyed by seven hours of exposure to the gamma rays.

5. In all three instances, about three-fourths of tumors which survived the roentgen and gamma radiations grew at much below the normal rate when the tumor fragments received a dose greater than about 60 per cent of the full lethal dose. In some cases the retarded tumor growth continued for several weeks and the tumor subsequently underwent complete regression, while in the others retardation lasted only from two to three weeks and growth was normal thereafter.

6. The Bunsen-Roscoe Law is applicable within the limits investigated for the roentgen irradiations of the tumor tissues.

I wish to express my thanks to Dr. G. Failla for his cooperation and helpful suggestions during the course of the present study.

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THE PRESENT STATUS OF ROENTGEN THERAPY WITH VOLTAGES ABOVE 200 KV.

TECHNICAL DEVELOPMENT AND MEDICAL APPLICATION

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CONTENTS

INTRODUCTION
I. Engineering of high voltage roentgen rays above 200 kv.
A. Emitting source (tube design).
(1) Sealed vacuum tubes.
(2) Open tubes operating with a pump: Coolidge multisectional tube; Lauritsen porcelain tube.
B. Energizing source (high voltage plant construction).
(1) Induction coil.
(2) Alternating current cascaded transformer.
(3) Direct current constant potential cascaded transformer.
(4) Other energizing sources: Villard, Witka circuits, etc.
(5) Sloan radio oscillator high voltage roentgen generator.
(6) Extremely high voltage sources used chiefly for physical research, but having medical possibilities: Brasch and Lange impulse generator outfit; Van de Graaff static machine.
(7) Lawrence and Livingston neutron radiation outfit.
C. General lay-out.
II. Medical application of high voltage roentgen rays above 200 kv.
A. Physical measurements.
(1) Quality determinations.
(*a*) Spectrometry.
(*b*) Absorption measurements.
(*c*) Voltage measurements.
(2) Quantity determinations.
(3) Energy absorption problems.
(*a*) Percentage depth dose.
(*b*) Surface back-scattering.
B. Biological effect.
(1) Dependence on quality.
(2) Biological dosage.
(*a*) Skin erythema.
(*b*) Deep-seated reaction (mucositis).
C. Clinical application.
(1) Indications.
(2) Clinical response and immediate results.
SUMMARY AND CONCLUSIONS.

INTRODUCTION

THE evolution of roentgen therapeutic methods has, from the beginning, been intricately interwoven with the technical development of energizing apparatus and especially of generating tubes. As long as pioneer artisans had to toil with static machines or primitively constructed induction coils and with "cranky" gas tubes in which nothing would keep constant, the results in the treatment of human ailments, by force of circumstances, had to be variable, irreproducible and, above all, inconclusive. With the advent of the transformer as an energizing source and a little later of the hot cathode Coolidge tube as the emitting source, some order was created in that domain in which the lesion was superficial or very near the surface of the body. The more deep-seated lesions, however, had to continue to remain untreatable until about 1920 when, finally, through modernization of roentgen engineering principles, the so-called "deep roentgen therapy" with 200 kv. was introduced. This, then, at once gave such an impetus to the whole art of the clinical application of radiation that the subsequent decade must be considered as the most fertile in the history of the entire science of radiology. Moreover, it appeared that the upper practical limit of technical development had been reached and that roentgenologists

could enjoy for a while the use of their newly perfected equipment, without fear that a change might be necessary before as much as a stabilization of an outfit was obtained, as had so often happened in the past. This assurance was apparently supported also by speculative physical argumentation that not a great deal of increase in the energy delivered to the various tissue depths might be expected from further raising the voltage of the generating source, the harder rays "shooting through" the tissues without further increasing the absorption.

basis of physical, biological and clinical observations, trying, finally, to arrive at certain conclusions concerning their application in practical therapy.

I. ENGINEERING OF HIGH VOLTAGE ROENTGEN OUTFITS ABOVE 200 KV.

A. *Emitting source* (tube design).

(1) Sealed vacuum tubes. The construction of sealed vacuum tubes for voltages above 200 kv. peak encountered several difficulties. First of all, the stress of the electric field would assume such tremendous proportions that the glass which was

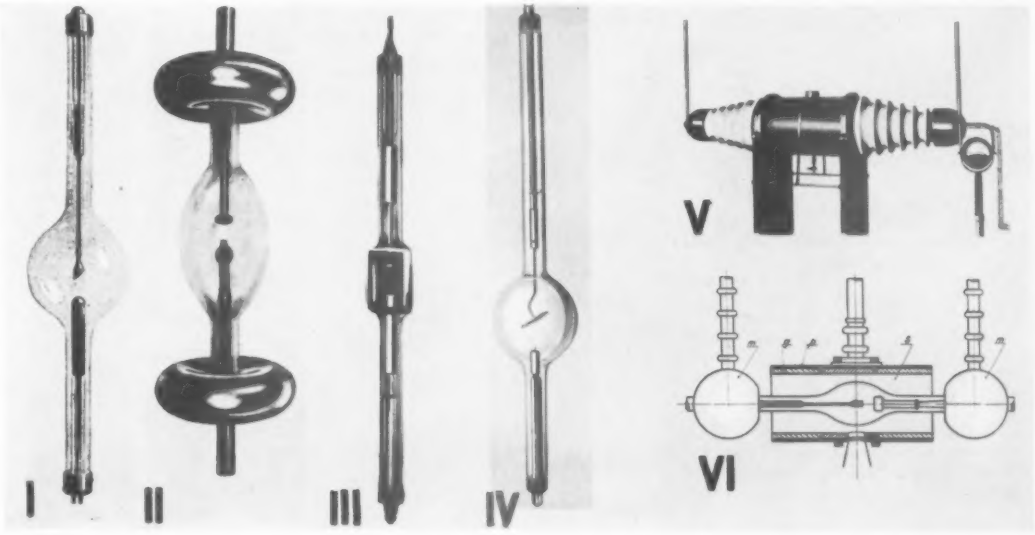

FIG. 1. Various sealed vacuum tubes for voltages above 200 kv. I. Gaiffe-Gallot Pilon tube (400 kv. constant, 2 ma.). II. Siemens-Pantix tube (400 kv. peak, 5 ma.). III. General Electric tube (340 kv., 10 ma.). IV. Westinghouse tube (300 kv., 10 ma.). V. Tuto oil-immersed protected tube (420 kv. peak, 5 ma.). VI. Osram-Kommandit (A.E.G.) tube (600 kv. peak, about 2 ma.): *m*, supporting spheres; *s*, protective cylinder; *g*, lead glass and *p*, pertinax wall. Note: These tubes being reproduced from various sources, their relative size as shown in the illustration does not represent their true relative size. (These tubes are reproduced through the courtesy of the various manufacturers.)

Yet we find that during the last few years a rather considerable number of machines have been constructed aiming to operate at voltages above 200 kv. peak, some of them being actually run at voltages as high as 500 to 1,100 kv. peak. It is the purpose of this paper (I) to consider the various types of such high voltage outfits from the engineering standpoint, and (II) to discuss their medical value on the

used as wall material could not withstand it; then the large corona effect which developed in the vicinity of the metal parts invariably led to puncture of the cathode neck and finally the copious back diffusion of the electrons from the anode produced a strong ionization near the cap of the anode neck with resulting damage to this end of the tube. More recently, by overcoming to a certain extent some of these

difficulties, as, for example, by replacing the ordinary glass with the stronger pyrex glass or porcelain, by providing protecting devices for the corona effect and by making use of the electron screen principle for the construction of the anode, roentgen tubes running at voltages as high as 300 to 400 kv. could be built (Fig. 1), not a few of which are already being employed in current practice. [3,15,41,51] Some of these [15,51] are oil immersed and surrounded with a lead protective shield, thus combining the idea of roentgen protection and high voltage tube design in a rather simple manner.

Coolidge[7] in 1930 introduced the so-called multisectional hot cathode roentgen tube (Fig. 2) which was the outgrowth of a laborious research work started some four or five years previously. The initial thought for the construction of this tube was given by the old Lenard cathode-ray tube which was modified by Coolidge in 1926 in order to permit the use of higher voltages (as high as 250 kv. maximum). Then the cascading method was applied, which in 1928 permitted the construction of a three-section cathode-ray tube operating at 900 kv., but it was clear that the method would

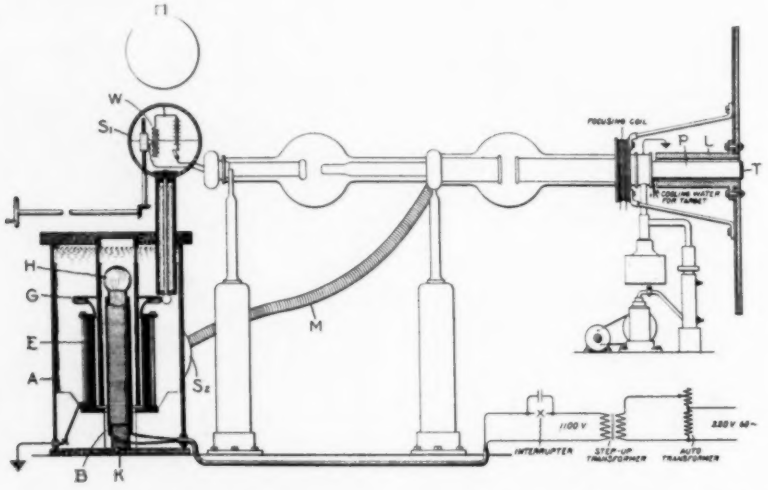

FIG. 2. Coolidge two-section cascaded glass roentgen tube with grounded anode and high tension induction coil for 700 kv. (Memorial Hospital). *A*, insulating cylindrical tank container of induction coil; *K*, core; *B*, primary; *E*, secondary; *G*, split aluminum spinning shield; *H*, spherical shield; S_1, 20 inch sphere which contains storage battery and remote controlled adjustable rheostat, *W*, and which connects to first section of tube; S_2, 20 inch sphere connecting *M* conductor to second section of tube; *P*, narrow long brass cylinder serving as head of the tube; *L*, protective sheet lead envelope and *T*, target. The tube operates with pump. (Published through the courtesy of Memorial Hospital, New York.)

(2) Open tubes operating with a pump. In attempting to build tubes for still higher voltages, it became evident that with all innovations, the vacuum of the tube could no longer be controlled in a satisfactory way. The idea of sealing the tube had to be abandoned in favor of a more flexible arrangement which would permit the actual pumping of the tube during the entire course of its operation. Two distinct roads were indicated in this respect by Coolidge and Lauritsen.

lend itself to the building of tubes running at any desired voltage when the difference of potential was equally distributed among the individual sections.* The following year, by making use of the same principle, a roentgen tube was constructed in two sections operating satisfactorily at 500 kv. (3 ma.), and soon afterward several tubes were made in three or more sections for still higher voltages. At the present time,

* Tuve, Breit and Hafstad,[52] for example, were able to construct a five-section cathode-ray tube operating at 1,900 kv.

this type of roentgen tube, which is from 12 to 14 feet long, is used in several installations running mostly at voltages between 500 to 700 kv., but it can be built—at least theoretically—for voltages as high as can be produced. A detailed description of the tube (as well as of the energizing outfit which first was an induction coil) can be found in a previous issue of this Journal.[7e] Its essential feature is that the cathode is in the first section of the tube near the high tension end and the target in the last section at the anode end, which is grounded. Since the cathode-ray beam must travel through the entire length of the tube, a magnetic focusing device is used to control the size of the focal spot at the target. This latter is made of tungsten thick enough to stop the electrons at that particular voltage and is soldered by means of a copper plate to a brass chamber, through which cooling water is circulated. The roentgen rays are taken out either in an axial direction, through the target, or in an angular direction from the face of the target, in which case the tungsten is made thicker. The envelope consists of glass one-quarter inch thick, the joints being sealed with wax. It may be mentioned here that although this multisectional tube was primarily designed to run on an induction coil, it will operate on any other type energizing apparatus.

At about the same time, Lauritsen[20] succeeded in constructing a high voltage roentgen tube on a somewhat different principle. He, too, started his work with the sectional glass tube, but applied the entire voltage to one end of the tube, instead of dividing it between the individual sections, as practiced in the Coolidge tube. Thus, in 1928, he was able to develop a four-section glass tube which without filament, on the basis of the Lilienfeld effect, could be run up as high as 750 kv. In 1930, this tube was modified, providing it with a hot filament and giving it a better target design. Finally, in 1931, procelain bushing was introduced as wall material and the present so-called Lauritsen porcelain roentgen tube constructed. The chief characteristics of this tube are that it is unisectional; that the filament-containing cathode end projects through the entire length of the tube within 20 inches of the target, the distance traversed by the cathode-ray beam being thus considerably shortened; that the anode end—as in the Coolidge tube—is grounded and, most important of all, that the envelope is made of thick porcelain. The great advantage of using porcelain as wall material lies in the fact that porcelain is more compact than glass and hence puncturing of the tube is practically avoided. On the other hand, the omission of elaborate internal shielding, which is

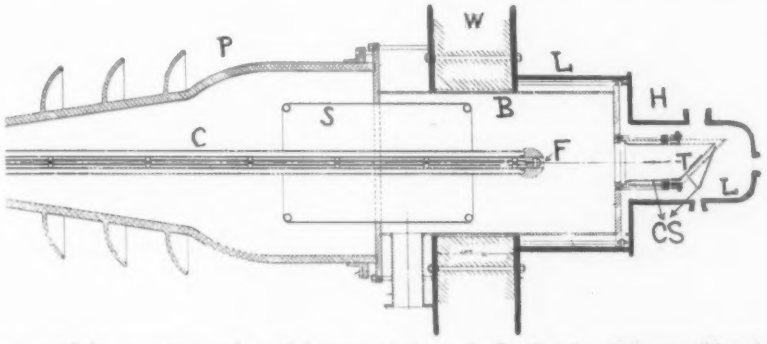

Fig. 3. Lauritsen porcelain roentgen tube, with grounded anode for 650 kv. (Harper Hospital). *P*, porcelain tail; *B*, steel body; *H*, head or ray emitting end, consisting of a narrow steel or brass cylinder, which is surrounded by *L*, protective sheet lead; *S*, metal shield cylinder against back-diffusing electrons; *F*, filament mounted in cup of the spherical cathode end; *C*, cathode stem; *CS*, cooling system using filtered tap water; *W*, concrete and lead protected wall of treatment cell. The tube operates with pump.

necessary in the glass tube, makes the construction of a porcelain tube relatively simple. The often heard criticism that a good vacuum cannot be maintained in porcelain is ill founded, for if the porcelain is glazed, no greater difficulty will be encountered in obtaining a good vacuum than in a glass tube of equal volume. A detailed description of the porcelain tube can be found in the *Review of Scientific Instruments*,[20c] except for certain changes in the construction of the roentgen-ray emitting end depending on the scope for which the tube is designed and which therefore must vary in different installations. The tube which is used at Harper Hospital (Fig. 3), and which embodies some innovations, is 13 feet long, and, briefly, consists of three parts: a porcelain transformer bushing, which forms the tail of the tube, starting with a diameter of 8½ inches at the high voltage end and terminating conically with a diameter of 22 inches; a steel tank, which forms the body of the tube, starting at the wider end of the porcelain cone with which it is joined together, passing through the wall of the treatment room to which it is grounded and terminating abruptly in the treatment room; and, finally, a small steel or brass cylinder which forms the head or roentgen-ray emitting part of the tube, the proximal end of the cylinder being attached to the steel tank and the distal end serving for the support of the target. In order to protect the porcelain from being punctured by the stream of electrons which result from cold emission from the anode stem, a metal shield, at ground potential, is extended inside the larger end of the porcelain for a distance of about one foot. The filament, which is made of annealed tungsten wire, is helical and is mounted in the cup of the spherical end of the cathode in such a manner that it can be easily removed, its replacement being necessary from time to time. We have two interchangeable heads of the tube, one of steel with a thin tungsten disk target, and another of brass, with a little thicker gold disk target. In both, the targets are mounted at an angle so that roentgen rays can be taken downward, sideways and upward, but there are now tubes with an elliptoid target in which the rays can be taken out in four or even five different directions. All installations making use of the porcelain tube with the ray emission at the grounded anode end are operating at voltages of from 500 to 700 kv. this being, for the present, the upper limit of the tube.

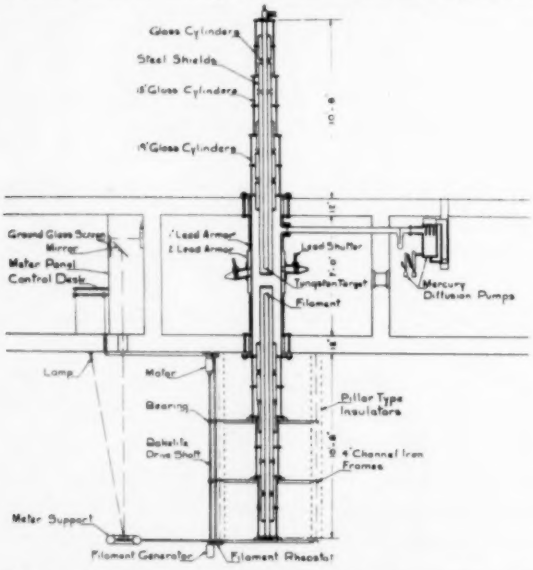

FIG. 4. Lauritsen mid-grounded glass roentgen tube for 1,100 kv. (Kellogg Radiation Laboratory of the California Institute of Technology). The tube operates with pump. The treatment cell is suspended in a concentric manner around the grounded midportion of the tube. (Reproduced through the courtesy of the California Institute of Technology.)

If, however, two of the above tubes are joined together, so that one end is connected to the positive and the other to the negative terminal of a high tension circuit, the midportion being grounded, the voltage which the tube will stand may be doubled. Such a tube was installed by Lauritsen in the Kellogg Radiation Laboratory of the California Institute of Technology (Fig. 4). Its design resembles very much that of an ordinary cylindrical roentgen tube using a metallic discharge chamber, except for the enormous dimensions, the tube being 31 feet long. The cathode end supporting the filament and the anode

end serving as target are located in the center of the tube, barely one foot from each other, so that the distance traversed by the cathode-ray beam is very short. The roentgen rays are taken out through four orifices of the lead shielded, grounded, midportion of the tube in four different directions, the treatment cell, the height of which corresponds to the jointed body of the tube, being suspended in a concentric manner around the tube. The tails, or arms, of this particular tube are built of three-sectional glass, several internal steel shields being used, for protection against puncturing, but they may also be made of the more compact porcelain. The tube has been operated satisfactorily at 1,100 kv. We may mention here that a similar tube, but of smaller dimensions, is being constructed by the Kelley-Koett Company for voltages up to 500 kv. This tube (Fig. 5) is very compact, measuring only 7 feet in length, has a grounded metal body which is surrounded by protecting lead and its two ends are made of porcelain. Additional lead protection is provided around the anode and cathode to prevent stray radiation. The target being oil-cooled, the tube can withstand a current of 15 ma. at 500 kv.

All these "open" roentgen tubes must be pumped continuously to maintain a good vacuum. Most of the pumping systems used at the present time consist of a two-stage mercury vapor pump backed by a "Megavac" oil pump. There is a liquid air trap in the vacuum line between the first vapor pump and the roentgen tube, for the absorption of the condensable vapors thrown out from the tube walls and electrodes during operation. This pumping system, although it has the drawback of consuming a large amount of liquid air, is quite fast and efficient. The tube will continue to operate with a small leak and after it has been opened up for replacing the filament or some other reason, it can be started up again within a few hours. The pipe leading to the tube is made, as a rule, of steel and terminates in the grounded body of the tube. More recently there is a tendency to use oil vapor diffusion pumps, which are similar to the mercury vapor pump, but among other advantages, consume considerably less liquid air.

B. *Energizing source* (high voltage plant construction).

The high voltage sources serving for the energization of the sealed vacuum roentgen tubes up to 400 kv. are, in the main, built on the same principles as those used for 200 kv., except that they are made of larger dimensions or put together with a greater number of serial units.[2,15,16,26,28,40,41] Likewise their mode of operation does not vary from that of the 200 kv. therapeutic apparatus.

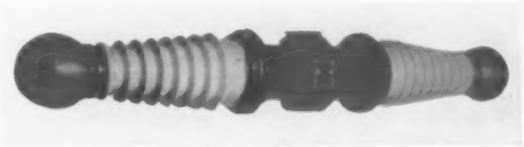

Fig. 5. Keleket mid-grounded protected porcelain roentgen tube for 500 kv. (operating with pump).

The introduction of the tubes running on continuous pumping, however, necessitated some innovations of construction. Thus, if the multisectional Coolidge tube is used, the high voltage must be generated in such a manner that it becomes equally distributed between the individual sections of the tube. On the other hand, if the entire voltage is applied to one end of a tube grounded at the other end or to two ends of a tube grounded in the middle, as in the Lauritsen tubes, it is necessary that the current be as free as possible of ripples or fluctuations which may lead to flashovers or cold emissions, with resulting damage to the tube. We will discuss in the following the three main types of high tension generators which are employed at present for the excitation of the open vacuum roentgen tubes above 400 kv.: the induction coil, the alternating current cascaded transformer and the direct current constant potential cascaded transformer, but will consider

also other types of sources which through further engineering improvement might find medical applicability in the future.

(1) The induction coil which until recently was used in only a few of the European installations for therapeutic purposes was reintroduced in the United States by Coolidge[7] in conjunction with the multisectional tube (Fig. 2). In this application, it consists of an insulating oil-filled cylindrical tank, containing the core made of sheet silicon steel, the primary and secondary windings and two arc-over protectors, one made of split aluminum spinning and the other of a specially constructed wooden spherical shield overlaid with narrow sheet aluminum strips. These two latter made it possible to go up with the voltage from 600 to 900 kv. If the tube is two-sectional, as in Figure 2, the lead to the first section is taken from the middle of the secondary through a metal sphere and a high tension conductor, and the lead to the second section directly from the high voltage end of the coil, through an oil bushing and a metal sphere which incidentally contains the storage battery for lighting the filament and the remote control adjustment. In case the tube has several sections, the voltage is taken off from an equal number of sections, from the secondary, being careful that the distribution is uniformly divided between the various sections. The interrupter is of the hydrogen-filled, mercury-turbine type, and the sphere gap consists of an overhead grounded sphere and the terminal sphere of the coil, checked against a standard gap.

The advantages of the induction coil as a roentgen energizing source at very high voltages, according to Coolidge,[7] are that it yields a sharp peaked wave, the useful voltage being, even with a considerable load, higher than the inverse (Fig. 11), a fact which is of decided importance for two reasons, first because it permits the utilization of the maximum voltage produced, if the tube is grounded at the anode end carrying the current in only one direction, and secondly because it makes possible the application of the sphere gap with certain reservations directly to the tube terminals; that the insulation required is less than would be the case with a sine wave; that the electrical and fire hazards, due to the high magnetic leakage, inherent in the open core, are diminished, and, finally, that the construction is of small bulk, simple and inexpensive.

(2) The interrupterless alternating current transformer has found great favor in America ever since the inception of the so-called deep roentgen therapy. This was due chiefly to the high efficiency resulting from the small magnetic leakage present in the closed core and to the relatively simple mode of operation. The apparatus consists either of one or two transformers, connected in parallel, and yields from 100 to 300 kv. peak. By cascading several units, it is possible to produce voltages of any desired magnitude. There are already a number of installations using such units operating at 500 to 700 kv. and the one at the California Institute of Technology operates at 900 to 1,100 kv. This latter consists of two banks of oil transformers, each containing five units of 200 kv. peak which are cascaded in the usual fashion. One transformer is connected to each end of the roentgen tube, the midportion of which is, as already mentioned, at ground potential.

The advantages of an alternating current transformer in energizing very high voltage tubes are that the voltage wave stays at its maximum for a longer period than in the induction coil (Fig. 11); that the rise and fall of the wave is at an equal rate, this rendering rectification rather easy and making possible the application of the current to tubes with both terminals alive; that the operation is simple; that the electrical efficiency is higher than in the induction coil; that the high frequency oscillations are greatly reduced and, finally, that the construction is rugged and, although more expensive than that of the induction coil, is still rather economical when compared to other types of installations.

(3) The direct current constant potential transformer apparatus has been used for therapeutic purposes with great success, especially in France. During the last few years, this type of energizing source started to create considerable interest also in the United States and there are now a number of outfits in practical use. Perhaps the most widespread among them is the type having an alternating current transformer, with two kenotron tubes and two condensers across the high tension circuit, in the so-called Latour connection. By cascading a number of these individual units, any desired voltage may be obtained in a very simple manner. The energizing plant at Harper Hos-

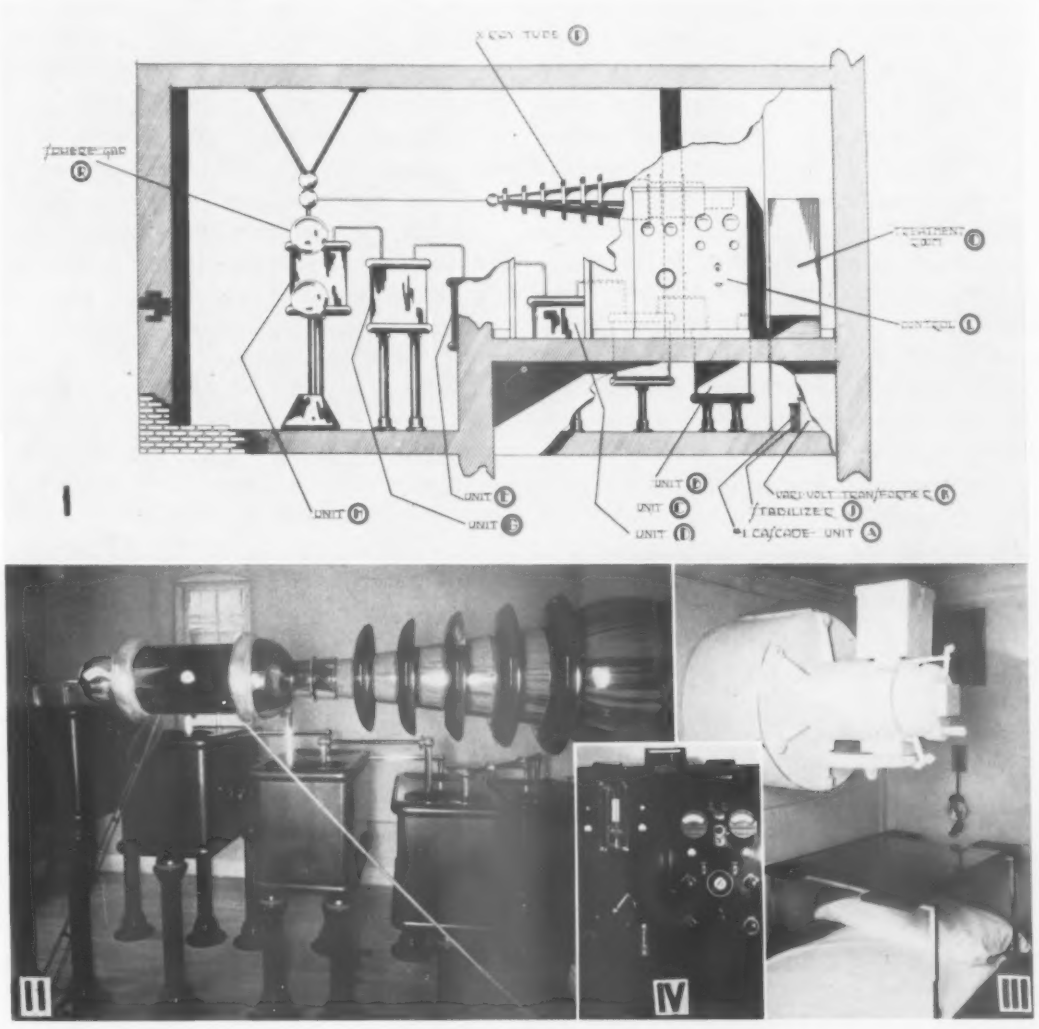

Fig. 6. Direct current constant potential porcelain tube roentgen plant for 650 kv. (Harper Hospital). I. Diagram showing the machine room with the six cascaded transformer units and the porcelain portion of the tube; the lead-protected treatment cell through the wall of which projects the grounded body and ray emitting head of the tube, and the overlapping control board which is in an adjacent heavily lead-protected room. II. Photograph of the machine room. III. Photograph of the treatment room. IV. Photograph of the control board, on the left control of the vacuum system, on the right control of the roentgen operation. At the top is mounted an ionization chamber for the permanent checkup of the roentgen output. The patient is observed through a periscope and verbal communication is made by means of microphones and loud speakers.

pital, which is of a similar type (Fig. 6) contains, for example, six 150 kv. units, each consisting of a step-up transformer, two kenotron tubes, two condensers of 0.05 microfarad capacity, and a cascading transformer of one-to-one ratio. The step-up transformers are fed by the alternating current of the power line through the intermediary of the cascading transformers. The outside case of each unit is insulated from ground and charged up to the potential of all of the preceding units, so that the electrical stress on any unit is only due to its own output. The units are connected in series with 175,000 ohms of wire wound resistance between each two. In this way rectification and filtering of the ripple is provided for in each unit with the result that the output is practically a pure direct current at any voltage. To prevent or minimize the effect of surging, and to protect both the tube and the generating plant in case the vacuum should break down, a one-half megohm water resistance is provided between the last unit and the aerial system. One end of the generating plant is grounded and the other end leads through the sphere gap and another metallic sphere, containing the filament storage battery and its control equipment, to the roentgen tube which, as already stated, is likewise grounded at the anode terminal.

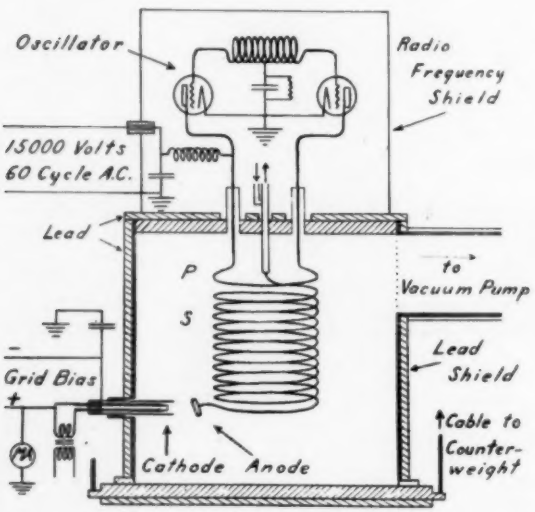

FIG. 7. Sloan radio oscillator high voltage roentgen generator for 800 kv. (University of California). (Published through the courtesy of Dr. Sloan)

The advantages of a direct current constant potential cascaded apparatus as a roentgen energizing source are that the voltage wave is practically a straight line (Fig. 11), leading to a maximum of efficiency and homogeneity in the output of the roentgen rays; that, for the same reason, it may be applied to tubes grounded at one end or middle; that the electrical efficiency is greatest; that the high frequency oscillations are nil, this safeguarding against punctures; that the operation is very smooth and, finally, that the measurements carried out on a roentgen tube energized by it are constant and reproducible. It must be stated, however, that it is more expensive than any one of the above mentioned outfits.

(4) There are, of course, other types of generating sources which may be used for the excitation of extremely high voltage roentgen tubes, as for example the apparatus based on the Villard,[2,16,26,40,41] Witka,[2] etc., circuits. Some of these are already being constructed for use with sealed tubes up to 400 kv. peak, but they may be made also for tubes operating with a pump at higher voltages. Especially the Villard circuit enjoys in this respect a very favorable position, its use as an energizing source becoming lately not infrequent.

(5) A place entirely apart is occupied by the apparatus of Sloan,[42] the so-called "radio-oscillator high voltage roentgen generator" in which the electrons are hurled against the target by the force of the highly positive anode. This apparatus was originated in collaboration with Livingood, Exner, and Lawrence, in the Physics Department of the University of California. Through the courtesy of Dr. Sloan, we are able to publish the following brief description of this unusual outfit (Fig. 7): Modern short wave high power radio technique has made possible a high voltage high frequency resonance transformer entirely free from insulating material, which can be mounted in an evacuated metal tank. One

end is grounded and the high voltage end freely supports a roentgen-ray target in the evacuated region. This resonance transformer, which operates at 6,000,000 cycles per second, consists of about 12 turns of heavy copper pipe with an internal water cooling system wound into a coil about 14 inches in diameter and equally long, and suspended by one end from the roof of the evacuated metal tank. A powerful radio transmitter sends its energy, not into an antenna, but into this resonance coil, which may be thought of as an antenna coiled up so that its radiation is negligible, the energy being dissipated instead by charging the coil up to very high potentials. This radio frequency power is generated by a push pull oscillator using a pair of special short wave radio tubes which are continuously exhausted, and have easily renewable filaments. These tubes can develop 200 kv. continuously at their high frequency, but in order to keep the resonance transformer coil cool it is desirable to operate the circuit with 60 cycle A.C. instead of D.C. To increase their efficiency, the oscillators are very strongly biased so that their average power input is only about 40 kw. when generating 800,000 volt roentgen rays. The filament is surrounded by a negative grid which prevents the escape of electrons except when the anode is near its most positive potential. An average emission of 5 ma. may really be short pulses which exceed 400 ma. Since the current flows only when the anode (or target) is highly positive, the effect is practically the same as high voltage D.C. operation of an ordinary roentgen tube. The main vacuum chamber is a steel cylinder one meter in diameter and equally high, with a flat top plate welded to it. The flat bottom plate, which is sealed to it with wax, is suspended by cables and counterweights to give access to the interior for initial adjustments of the coil and electrodes. The vacuum diffusion pumps use Apiezon oil instead of mercury, and require no vapor traps for voltages up to 800 kv.

The outstanding advantages of this outfit are its compactness, low cost and extreme ruggedness. No high voltage exists outside of the vacuum and the complete equipment occupies less than 6 by 12 feet of floor space, and is 12 feet high. No serious breakdown can possibly occur. The operation is as steady as the voltage of the power supply lines. A second complete installation of this kind has just been made, with the aid of Dr. M. S. Livingston, at the Medical School of the University of California, and is being used by Dr. R. S. Stone and his associates, for medical treatment.

(6) We may include here two other sources of extremely high voltages which were primarily designed for the study of atomic nuclear disintegration, but which

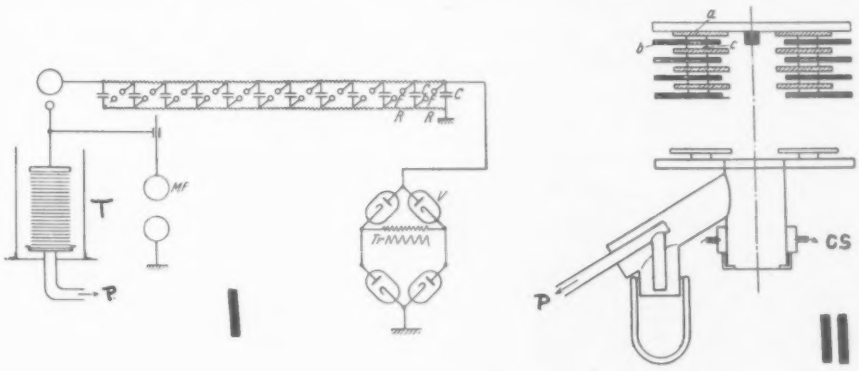

FIG. 8. Brasch and Lange impulse generator outfit for 2,500 kv. I. General diagram: *Tr*, transformer; *V*, valve tube; *R*, resistance; *C*, condenser; *MF*, sphere gap; *T*, vacuum tube; *P*, pump. II. Diagram of tube; *a*, metal disks; *b*, cardboard disks; *c*, rubber rings; *CS*, cooling system. (Reproduced from *Strahlentherapie*.)

eventually may be modified to serve for medical purposes. The one is the so-called impulse generator (Stossspannung) outfit of Brasch and Lange,[4] the other the static machine of Van de Graaff.[53]

The impulse generator outfit was constructed on the principle of Marx for a range of 2,500 kv., but there is now a

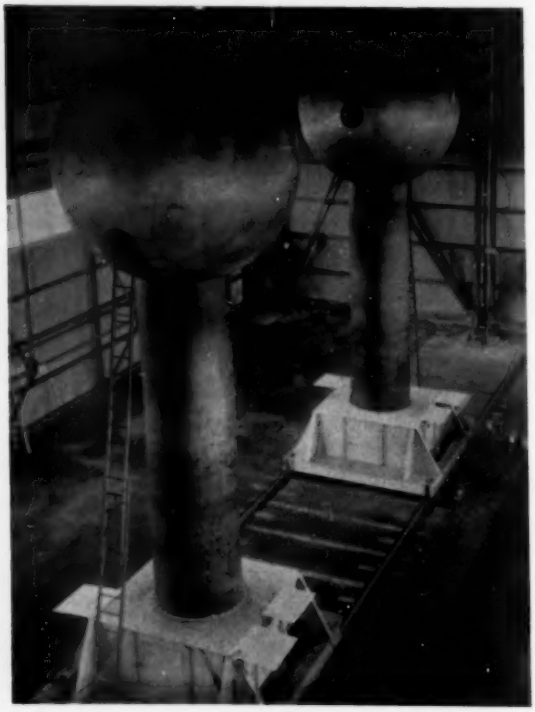

FIG. 9. Van de Graaff static machine for 7,000 kv. (Wide World Photo).

second installation under consideration for voltages as high as 7,000 to 10,000 kv. The increase of voltage is obtained by leading the current of a constant potential source through condensers charged in parallel and discharged in series to a terminal sphere, from which it flashes over to the ray emitting tube (Fig. 8). The energization occurs, as can readily be seen, in the form of impulses corresponding to the discharge duration of the condensers, which in the 2,500 kv. outfit is of the magnitude of 10^{-4} to 10^{-6} seconds. Since the individual impulses represent large currents, a tube emission equivalent to 1 ma. continuous current may be obtained if only 1 impulse per second energizes the tube. This particular form of energization permits the construction of a very rugged ray emission tube. In the outfit of Brasch and Lange, the walls of the tube are made of alternate hollow disks of metal and cardboard, intermediate rubber rings being used for insulation. The cathode end of the tube includes a hot filament, and the anode end is fitted with a window in case cathode rays are produced or with a target in case roentgen rays are desired. A continuous pump is provided for the maintenance of the vacuum, and circulating water is used for the purpose of cooling. The entire generating source, including the tube, can be immersed in oil so that the complete outfit will occupy a very small space. Although the primary purpose of this installation, as already stated, was physical research, very recently Back and Halberstädter have undertaken certain investigations from a medical standpoint. To take one single example, they found that the energy of a single impulse is so great that mice exposed to it from a distance of 100 cm. died within a few days and that only after a 1000-fold reduction of the intensity of the radiation could therapeutic investigations be started.

The static machine of Van de Graaff (Fig. 9) yields voltages as high as 7,000 kv. Essentially it consists of two hollow spherical aluminum electrodes 15 feet in diameter, mounted on insulating pedestals of textolite, 6 feet in diameter and 24 feet high. Each of the spheres is charged to a potential of 3,500 kv. by means of paper belts, which operate self-exciting within the hollow pedestals by running vertically from the driving motors at the base to the pulleys within the spheres. The electrical charge carried up by the belts is conveyed to the spheres by collecting brushes and stored on their surface until a sufficiently high potential produces a flashover. Van de Graaff now has a vacuum tube under construction which may be placed in the space between the two spheres permitting a flow of steady constant potential current which

by exciting a target would lead to the emission of roentgen rays more powerful than the gamma rays of radium. It is interesting that the worker operating this installation occupies the interior of one of the aluminum spheres which is equipped with various control and research instruments.

(7) Finally, we are including the method of Lawrence and Livingston[24] for the generation of very high speed electrons and ions without the use of high voltages, although the method is primarily designed for entirely different purposes than the production of roentgen rays. It can be readily seen from the preceding paragraphs that the electrons serving for the bombardment of a roentgen target are accelerated in a straight-forward fashion by increasing either the pushing force of the negative terminal, as is the case of most apparatus, or the pulling force of the positive terminal, as in Sloan's outfit, or, finally, by a combination of both, as happens in the midgrounded tubes. The merit of the new method which was evolved during the past three years by Lawrence and Livingston[24] is that the speeding up of the electrons is brought about by a system of multiple acceleration with the aid of an oscillating electric field and an adjusting magnetic field. For this reason, the method can be applied to all charged particles, particularly to the positively charged protons and to all sorts of ions, thus greatly facilitating the study of physical nuclear excitation which may serve to explain to a certain degree also the phenomena of biological cellular excitation. Moreover, very recently, Lawrence and Livingston announced the realization of the so-called "neutron

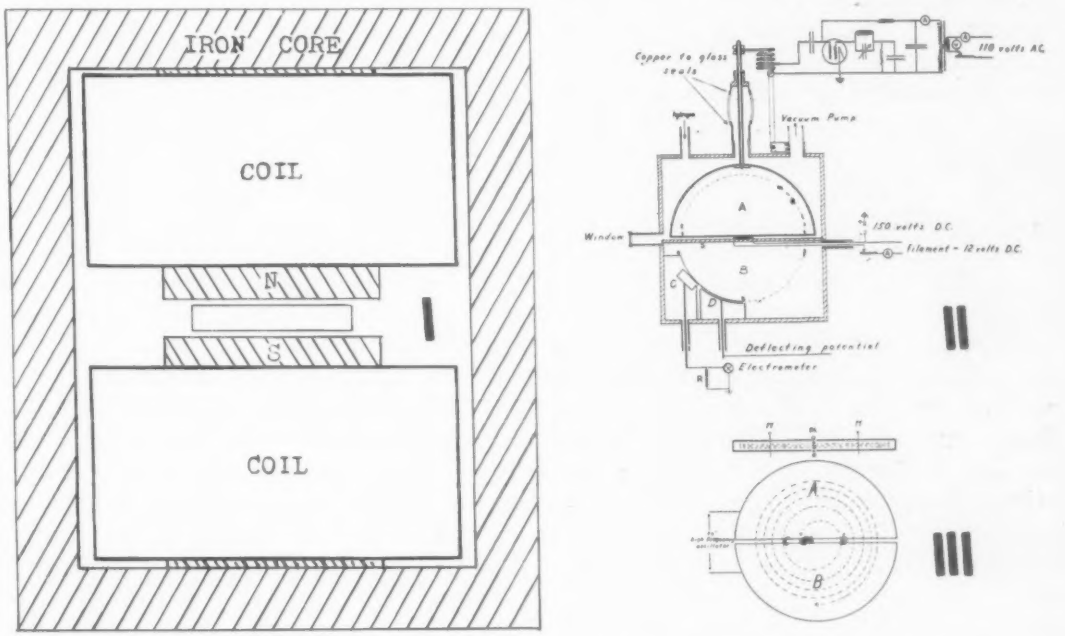

Fig. 10. Lawrence and Livingston neutron radiation outfit. I. Diagram showing huge magnet for production of magnetic field and position of the vacuum tube between the *S* and *N* pole faces of the magnet. II. Diagram of vacuum tube (viewed from above) and of source for the production of the oscillating electric field; *A* and *B*, semicircular hollow plate electrodes; *C*, Faraday collectors; *D*, electrostatic deflecting plates: *S*, brass dividing wall, provided with slits. III. Diagram of multiple acceleration of ions: upper, showing the revolution of ions within the vacuum tube sideways, and lower, looking from above. As is noted, the ions (*a*) revolve in ever widening semicircles, gaining an increased energy on each crossing of the diametral region (*b*, *c*, etc.). (University of California.) (II and III reproduced through the courtesy of Dr. Lawrence.)

rays" in quantities which may assume practical importance. These rays consist of particles emitted in a neutral state, that is, having neither a positive nor a negative charge, which, therefore, have great penetrating power, being able to pierce the nuclear potential walls without obstacle. As we now know, the cathode rays, which are streams of negative electrons and which a few years ago were expected to acquire with higher voltages, up to 2,000 kv.,[52] a certain practical importance in the treatment of cancer, have failed to fulfill these expectations just because of the lack of penetration, the superficial layers of the cancer absorbing all of the radiation delivered, in a manner similar to the absorption of the beta rays of radium, and nothing reaching the deeper parts. A beam of protons, if produced in a pure state, may, in this respect, have an even worse fate, for the penetration, like that of the alpha particles of radium, is of still less efficacy. The neutron rays, however, by virtue of their zero charge may traverse all depths of a cancer or a human body in such a way and set up phenomena of such importance as to be of the utmost practical value either in single application or in combination with the already well-established irradiation procedures with roentgen or gamma rays. In the present arrangement of the California laboratory, they are produced in a stream of 10,000,000 neutrons a second and with a kinetic energy equivalent to 3,000,000 volt-electrons, but by further increasing the acceleration an equivalence of 10,000,000 volt-electrons or even higher is easily practicable. The method of generation is, briefly, as follows: Deutons, which are the cores of the newly discovered heavy hydrogen atoms, or any ion if used for other purposes, are accelerated in a vacuum tube spirally to a desired speed and then whirled against a target which may be of various materials. As shown in Figure 10, the vacuum tube has the shape of a flattened hollow box made of brass, which is placed between the two pole faces of a huge magnet. By removing the cover of the box, one may see: the filament above the diametral region, from which a stream of electrons passes along the magnetic lines of force, generating ions of gases in the tube; the *A* and *B* electrodes, not unlike duants of an electrometer, which produce an oscillating electric field over the diametral region between them; *S*, brass dividing wall, which has slits of the same dimension as the opening of the nearby electrode for the passage of the spirally revolving ions from one electrode plate into the other; *D*, electrostatic deflecting plates, which serve to increase the radius of curvature of the paths of the high speed ions to allow them to enter the Faraday collector *C*, where they are hurled with the final speed acquired against the metal target. The acceleration is provided by the electric and magnetic fields, the first causing the ions to move in resonance with the high frequency oscillations applied to the plate electrodes *A* and *B*, within the interior of the electrodes and the second bending them on a circular path so that they may pass from the interior of one electrode to the interior of the other. As a final result, the ions will revolve in ever widening semicircles, gaining an increased energy on each crossing of the diametral region. By properly adjusting the electric and magnetic fields, it is possible to bring about such a sharp focusing that the beam of high speed ions at the Faraday collector has a width of less than one millimeter. This beam then collides with the target. In the case of the deutons, from the impact result streams of protons and neutrons. It is interesting that the neutrons penetrate heavy atomic elements, as for example, lead, easier than light ones. In passing through paraffin, they smash hydrogen nuclei setting free recoil protons, the process being not unlike that observed in the course of absorption of roentgen quanta. Considering the richness of cancer and human tissues in the hydrogen element, one cannot conjecture enough about the value of these rays in their practical therapeutic application.

C. *General lay-out.*

The general lay-out of high voltage installations utilizing sealed tubes above 200 kv. does not differ from the orthodox deep roentgen therapy units, as used for 200 kv., except, of course, for the heavier lead protection, which is necessitated both around the tube and in the walls of the treatment room. If, however, a tube provided with a pumping system is used, conditions change materially. Because of the increased thickness of lead which must be used, and especially because of the large dimensions of the housing required to safeguard against the electrical hazards and the stray radiations emanating from the back of the tube, here architectural problems come to the foreground, forming, no doubt, the most important phase of the construction. In another publication[25] we have dealt *in extenso* with these problems, and would, therefore, refer those interested to that article.

II. MEDICAL APPLICATION OF HIGH VOLTAGE ROENTGEN RAYS ABOVE 200 KV.

The effect of any therapeutic agent on the human body is best analyzed by studying: (A) the physical state of the agent at the point of action; (B) the biological reaction of the tissues, and (C) the clinical response of the lesion upon which it is used. In all instances the governing factors remain (1) the quality, (2) the quantity and (3) the energy, or amount absorbed, of the administered agent. We may study, although perhaps a little too academically, the therapeutic effect of the roentgen rays above 200 kv. from the standpoint of the same factors.

A. *Physical measurements.*

The roentgen rays being primarily a physical agent of a very complex nature and leading in the process of action to phenomena which are exceedingly difficult to interpret, every physical measuring procedure must be chosen with much care and executed with great thoroughness.

(1) Quality determinations. During the course of time and especially since the introduction of deep roentgen therapy, a great number of methods have been suggested for the characterization of the quality of a roentgen beam. A brief review of these methods, as applied at present for 200 kv., may appear useful. They may be roughly divided into three groups (*a*) spectrometry, (*b*) absorption measurements and (*c*) voltage measurements.

(*a*) Spectrometry. This is the most precise from a physical standpoint because it permits the direct evaluation of two essential factors: the magnitude of the shortest wave length, and the spectral distribution of energy. Its application to practical roentgen therapy, however, is difficult because of the cumbersome apparatus and greatly complicated technique involved.

(*b*) Absorption measurements. These may be divided into three groups: indirect wave length determinations, half-value layer method and coefficient measurements (some also include the depth dose measurements). The determination of the wave length from absorption data was introduced by Duane[8] who measured the percentage of the radiation passing through 1 mm. copper or 4 mm. aluminum and from comparison with spectrographic measurements plotted standard curves which are used for reference. He called the value of the wave length so obtained the "effective wave length," and defined it as the wave length of the monochromatic roentgen ray that has the same absorption as the whole beam of rays in any particular case. Later other similar methods were introduced, such as the "average wave length method" (Mutscheller[30]), the "true effective wave length method" (Taylor[47]), the "bracket method" and some half dozen other methods for the determination of the effective wave length,[32,47] all based on some sort of absorption measurements. The half-value layer method, which was one of the earliest and perhaps the most heralded of all quality methods, is relatively simple: all one has to do is to determine the thickness of a filter (most commonly aluminum or cop-

per) necessary to reduce the intensity of the initial roentgen beam to one-half. Because of its simplicity, it has found great

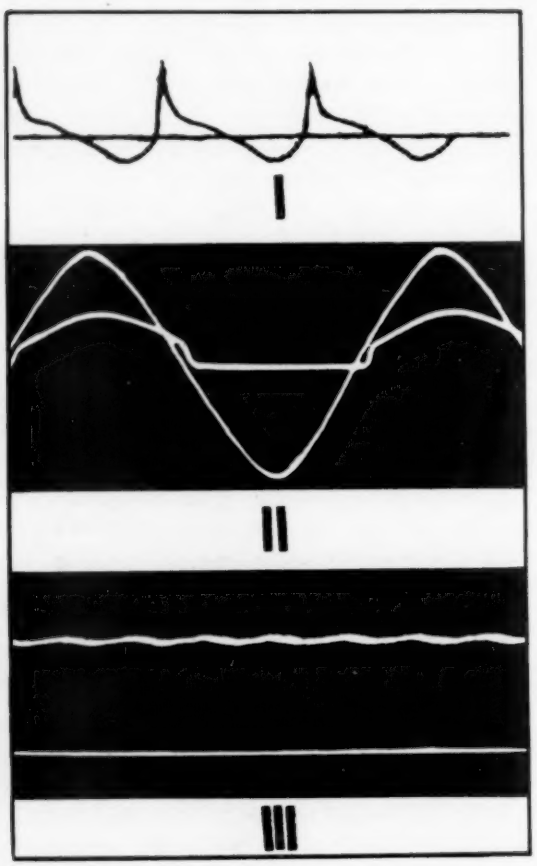

FIG. 11. Comparison of the energizing waves of the three main types of apparatus: I. Diagrammatic representation of the voltage wave form of a coil. II. Oscillograph of an alternating current transformer generator, the sine wave representing the voltage (550 kv. peak) and the half wave the current (average value 4 ma.). III. Oscillograph of a direct current constant potential cascaded transformer generator, the upper line representing the voltage wave (500 kv. constant), there being practically no rippling, and the lower the current (5 ma.).

favor with many roentgenologists in Europe and it seemed as though it would have sufficient accuracy to become of general practical use. More recently, however, Quimby,[34] by studying the quality of various radiations, all having the same half-value layer in copper, demonstrated that a great difference in their depth doses, which is the most important factor from the therapeutic standpoint, may exist. A similar opinion was expressed by Holthusen and Gollwitzer,[18] by Taylor,[47] and others. The various coefficient measurements include the determination of the absorption coefficient, which, in the light of our present knowledge of absorption conditions, is a rather vague term and is assumed to represent the percentage of the initial radiation absorbed per unit thickness of filter; the attenuation coefficient which is more precise, and represents the percentage of the initial radiation transmitted per unit thickness of filter; the homogeneity coefficient which is a function of filter and voltage, and some others. Lately, to better characterize the energy distribution in a beam as heterogeneous as the roentgen beam used for therapeutic purposes and to somewhat bridge across the gap existing between the above absorption methods, Pohle and Barnes,[32] Burby and Barry,[5] Pohle and Wright,[33] Wilsey[54] and Taylor[48] proposed that the full absorption curve (log 1 or log 1/Io plotted against filter thickness) in copper or aluminum be used for the specification of quality. According to Wilsey,[54] such a procedure has the following main advantages: It is uniquely related to the spectral distribution of the intensity, it discriminates more accurately between different qualities of roentgen rays than other methods of quality specifications, it is adequate to distinguish radiation having appreciably different absorptions in tissue and, finally, other methods of roentgen-ray quality specification, such as effective wave length, half-value layer, absorption coefficient or homogeneity coefficient, may be derived from it.

(*c*) Voltage measurements. There can be no doubt that in the state of our present knowledge, spectrometry and the determination of the absorption curves represent the best physical methods for the general description of the quality of a roentgen beam and that most of the other procedures have definite values in specifying certain

particular characteristics. Yet a perusal of the international literature dealing with roentgen therapy for the past ten years, for example, reveals the surprising fact that the overwhelming majority of roentgenologists still prefer to express the factors pertaining to the quality of the radiation in terms of voltage and filterage by specifying the type of generating apparatus used, and adding rarely the value of the effective wave length, the half-value layer, or the absorption coefficient, merely to be complete. That such a procedure is not the most accurate, when it comes to translating results from one apparatus to another, is quite obvious, but it has the advantage that, when an apparatus is once standardized, it permits a duplication of a treatment on the same apparatus in a rather simple manner, assuming, of course, that all factors remain unchanged during the course of operation. Recently Taylor[48,49] has tried to find some basis which would permit the reproduction of irradiation conditions on all types of apparatus expressed in terms of potential. Working with voltages up to 230 kv. obtained from mechanically rectified and constant potential generators, he measured the emission of a roentgen tube, as it varies with peak voltage, with average voltage and with effective voltage per unit tube current and found that when the potential is expressed in effective (root-mean-square) kilovolts and the filter remains the same, the roentgen-ray emission of a tube is equivalent to that produced by very nearly the same constant potential. This, then, permits expression of all radiations in terms of that excited by a constant potential generator, greatly simplifying the correlation of different types of machines. It must be mentioned, however, that Taylor's investigations did not include the very rugged, peak-topped potential obtainable from an induction coil source.

In analyzing the suitability of the above quality methods for the characterization of the radiations emitted by various sources above 200 kv., we find that spectrometry is difficult to apply, necessitating the construction of special spectrographs[21] and that the absorption curves, though of great aid in permitting an insight into the energy distribution of the particular beam, are of little value in establishing practical criteria from which some sort of a dose (principally erythema) dependence may be derived. Thus here, too, the indication of the voltage and filterage, with the specification of the type of apparatus used, appears preferable from a practical standpoint. However, because of the increase in the roentgen emission per unit tube current with increasing voltages, the difference of reading, and thus the error with various apparatus, will be considerably greater than in the voltage range below 200 kv. A study of the exciting wave form and the dependence of the roentgen emission on it is very instructive in this respect. An induction coil source, for example, yields, as already mentioned, a very steep, peak-topped wave (Fig. 11), the excitation of the tube target occurring in the form of brief, abrupt impulses, whereas the alternating current generator produces a sine wave which is more broad-topped and which consequently bombards the tube target for a longer period, leading to a larger roentgen-ray emission than the former. The constant potential source having a wave which is practically a straight line, assuming, of course, that there is no rippling present, produces the maximum roentgen-ray emission. Since in all these apparatus, the voltage is measured with a sphere gap, it is clear that the peak of the wave, regardless of its shape, is determined in every instance. This, then, gives a very false idea concerning the quality of the roentgen beam emitted, a fact which, as we shall see later, is of paramount importance in evaluating the dose (number of roentgens) which is necessary to produce a certain biological reaction, as, for example, an erythema. Theoretically, the ratio of the effective value to the maximum of a sine wave is 1.4 and to the peak of an induction coil wave still a little more, but in the field of roent-

gen energization at very high voltages, this ratio dwindles down to a certain extent. Inasmuch as the short wave length limit of a roentgen spectrum depends on the maximum of the exciting voltage wave an alternating potential machine may be brought, by properly adjusting the filament so that electrons pass only during the maximum of the wave, to the point where it delivers the same or nearly the same short wave rays as the constant potential machine operating at an identical voltage (as measured by the sphere gap), but when it comes to estimating the intensity of the spectral distribution, which depends on the shape of the exciting wave, there will remain a decided difference. In the induction coil apparatus, this difference is still more marked and is present also in the range of the short wave limit of the spectrum. It results, therefore, that some other way of measuring or expressing the potential than the peak voltage must be found, if the system of specifying the quality of a certain roentgen beam in terms of voltage is to be continued. Perhaps the method of Taylor in determining the "effective (r.m.s.) voltage" may be extended also to potentials above 230 kv., but with this procedure, the filterage and the effect resulting from its variation must also be stated separately in every instance.

Lauritsen[22] very recently advanced the idea that the quality of a roentgen beam be expressed in "equivalent voltage." This he defined as that voltage which is required to produce radiation of equivalent wave length. In turn, equivalent wave length was characterized as that wave length of monochromatic radiation which has some predetermined measurable property in common with the beam in question. The attenuation in water was chosen as the most suitable measurable property, because it

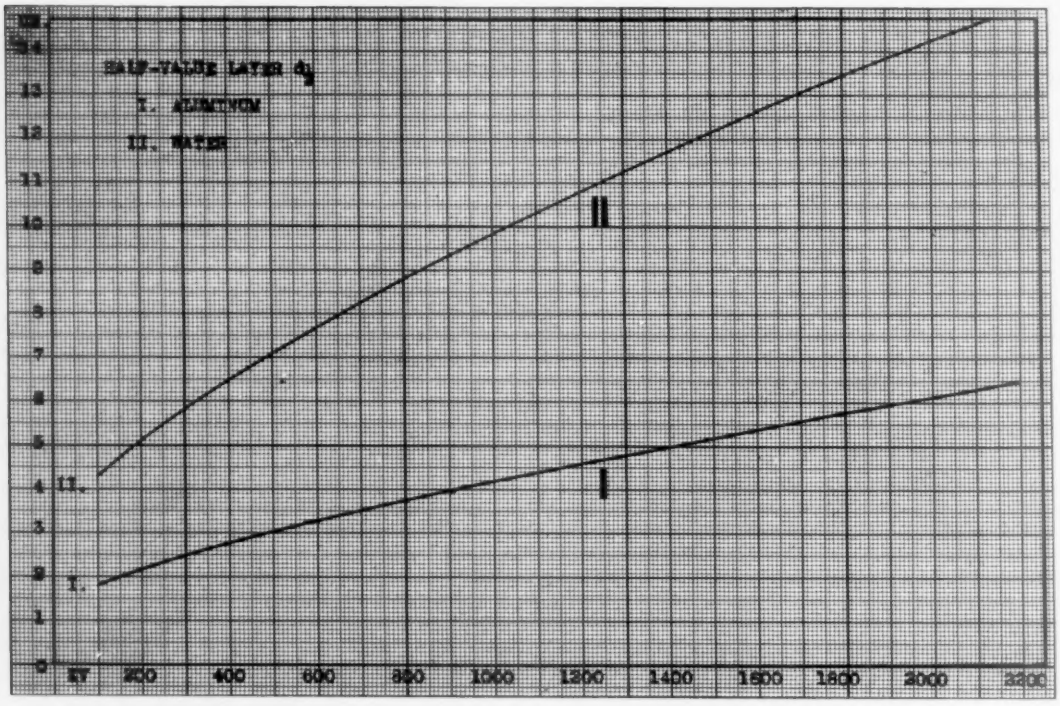

FIG. 12. Calculated half-value layer ($d_{1/2}$) for monochromatic radiation between the range from 100 to 2,200 kv. I. Aluminum. II. Water (Lauritsen).

nearly parallels attenuation conditions in the human body and because it can conveniently be expressed in terms of half-value layer. A curve of this latter (Fig. 12, II) was calculated for monochromatic radiation for the range 100 kv. to 2,200 kv., with the aid of attenuation coefficient values obtained from the Klein-Nishina formula. The practical procedure of Lauritsen thus becomes a very simple one. The roentgen tube is operated with the filters in place at the desired voltage, and the half-value layer of water is measured, best with a standard ionization chamber, for that voltage. The value so obtained is then compared with the half-value layer of water for monochromatic radiation as shown in the curve and the "equivalent voltage" noted. Such a procedure has the great advantage, as we shall see later, that it permits a rather easy correlation of the quality and quantity (number of roentgens) of radiation necessary to produce a certain biological effect. We are also including a half-value layer curve in relation to equivalent voltages for aluminum which can be handled a little easier than water (Fig. 12, I). Aluminum was chosen, instead of copper or other material of high atomic weight, to eliminate as much as possible the photo-electric absorption, since it is assumed that the attenuation of the roentgen beam in light elements occurs above 100 kv. almost entirely by scattering. There is very little difference in this respect between aluminum and water. In carrying out the actual measurements, certain precautions must be observed in addition to the usual regulations associated with ionization measurements, if a standard "free air" ionization chamber is used.[22] Thus the roentgen beam must be very narrow to eliminate degraded radiation and must pass through the chamber centrally without hitting the side walls, to prevent wall effect; then, the side walls of the chamber must be made of light material, as for example aluminum, and back-scattering from the opposite wall (floor, ceiling, walls of treatment room) must be avoided; finally, the medium to be measured (aluminum or water), as well as the limiting diaphragm, must be placed at a certain distance from the measuring volume of air so that they will not increase the ionization by scattering of their own.

In concluding this very complex chapter of quality determinations, it seems to us that the Standardization Committee of the International Congress of Radiology would accomplish a very useful task in trying to establish a standard procedure of quality measurements in a manner similar to the quantity measurement. This would aid considerably in the unification of therapeutic results, especially when the higher voltages are applied more generally.

(2) Quantity determinations. The introduction of the international unit, the roentgen (r), in 1928 has greatly simplified the problem of the physical measurement of the roentgen quantity. Although much has been written since that time for and against this unit, it may be said that its use in practical roentgen therapy up to 200 kv. is now nearly general. Moreover, the work carried out by Glasser and Meyer,[11] Glasser and Portmann,[12] Behnken and Jaeger,[18] Taylor,[50] Kaye and Binks,[19] and Solomon[45] has brought the realization of the unit to such a fine degree of accuracy that an error of only ± 0.5 per cent is found in the various national laboratories serving as bureaus of standards.

In extending the use of the roentgen for quantitometric measurements above 200 kv., the question arises, however, whether or not the more penetrating roentgen rays do not influence the ionization of the air on which the realization of the roentgen is based in such a way that an appropriate correction may be necessary. As is well known, the International Committee of Standardization, in defining the roentgen, imposed certain conditions of measurement, but was careful not to specify the type of apparatus which must be used, thus leaving the experimental and practical realization of the unit entirely in the hands of the various bureaus of standards. During the course of time, especially two

types of ionization chambers have been developed, the "free air" chambers, in which the roentgen beam enters the volume of air to be ionized through a limiting diaphragm, and the thimble chambers in which the volume of air ionized is surrounded by a wall which must be void of "wall effect" and independent of the wave length. The first are more suitable as primary standard chambers, whereas the second are used chiefly in connection with dose measurements around the patient. A re-calibration of the second in values of the first is from time to time necessary. Now, as Failla, Quimby, Marinelli and Rose[46] have found out, there are several serious difficulties which prevent the quantitometric measurement of the ionization of the volume of air with increasingly higher voltage in the "free air" chambers, a fact which must also have a repercussion on the accuracy of standardization of the thimble chamber. One of these presumably is the presence of recoil electrons of very long paths which are set in motion in the neighborhood of the chamber, adding to the ionization of the volume of the air measured; another, the increasing fraction of the degraded radiation which is absorbed in increasingly larger volumes of air; a third, the corresponding increase in the absorption of back-scattering of the degraded radiation, and so on. Obviously, further investigations are necessary before the ques-

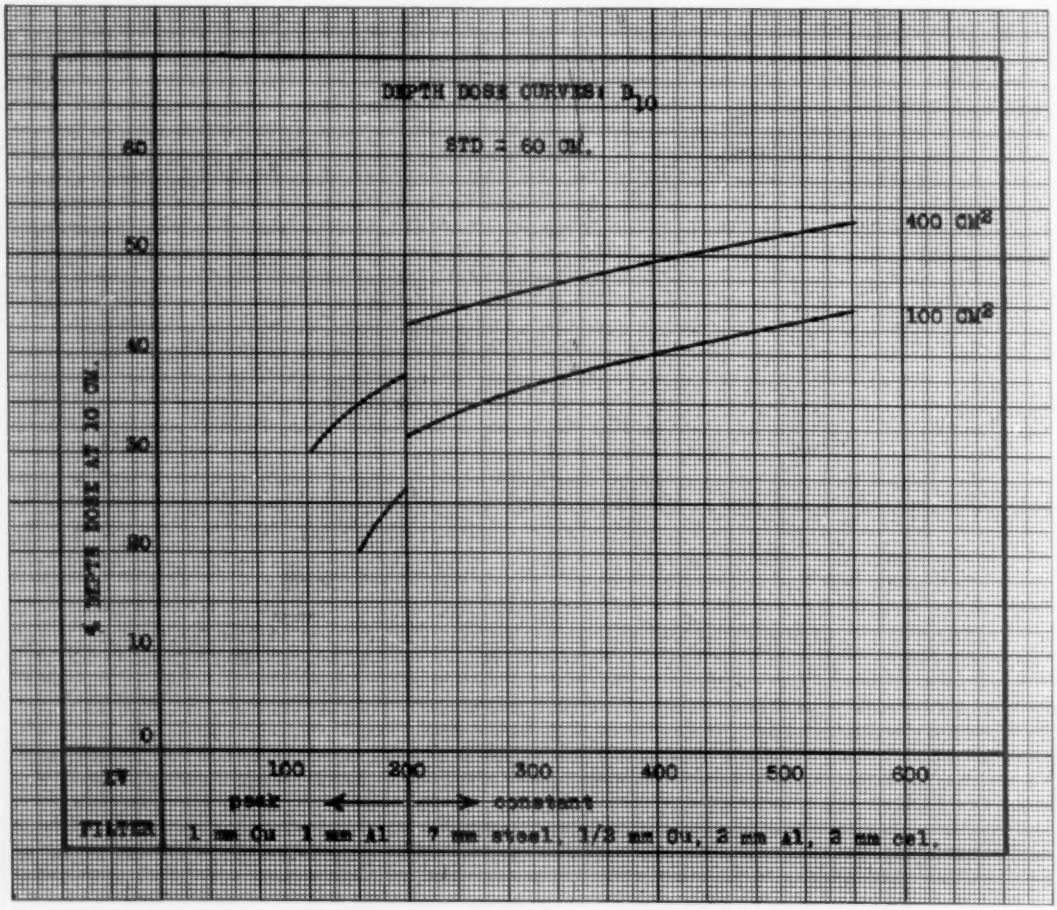

FIG. 13. Depth dose curves: D_{10}.

tion can be settled in a satisfactory manner. It may be mentioned, however, that Hermann and Jaeger[17] found that the wall of the thimble chambers most frequently used in dosimetry is sufficiently thick to absorb up to 600 kv. the secondary electrons from the neighborhood, and that Mayneord and Roberts,[28] by comparing the air wall chamber with the parallel plate chamber, traced the difficulty in this latter to recoil electrons in the surrounding air.

We have used the roentgen in its meaning as determined for voltages up to 200 kv. The Glasser condenser meter[13] was employed mostly around the patient and in absorption measurements, and small cable connected celluloid ionization chambers and a large "free air" ionization chamber with the necessary precautions as mentioned in the former paragraph were utilized for the purpose of comparison. The values referred to later are expressed in terms of roentgens as measured with these instruments, it being understood that their correction may prove necessary in the course of time.

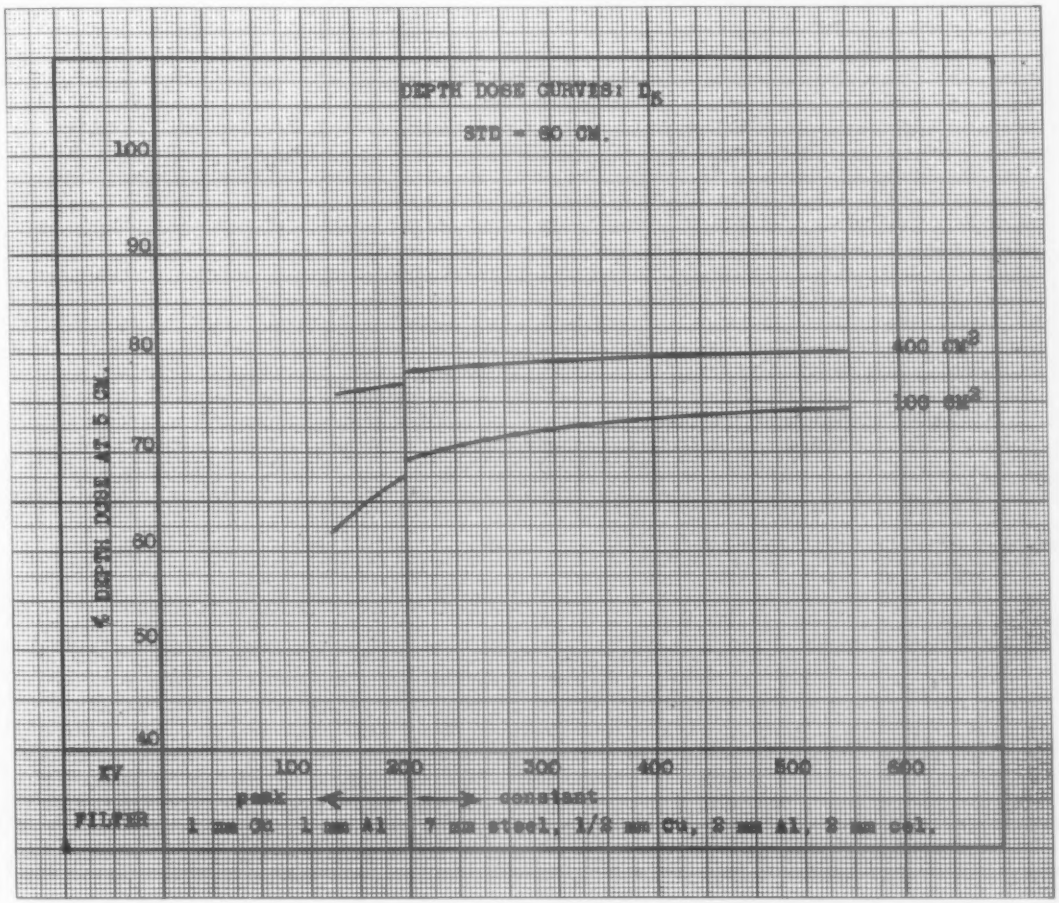

Fig. 14. Depth dose curves: D_5.

We would like to digress here for a moment to stress the fact that the expression of the roentgen quantity in milliampere-minutes, as so often practiced formerly, must be completely abandoned. First, there is such a variation in the in-

tensity (r/min.) of the roentgen-ray output in the higher voltage field in relation to potential and tube current that this cannot be expressed in simple numerical values convertible in time of exposure, and, second, the milliamperage loss depending on some place in the direction of the beam (Fig. 6). In this respect, an additional daily control of all factors pertaining to dosage measurement is also recommendable.

3. Energy absorption problems. In at-

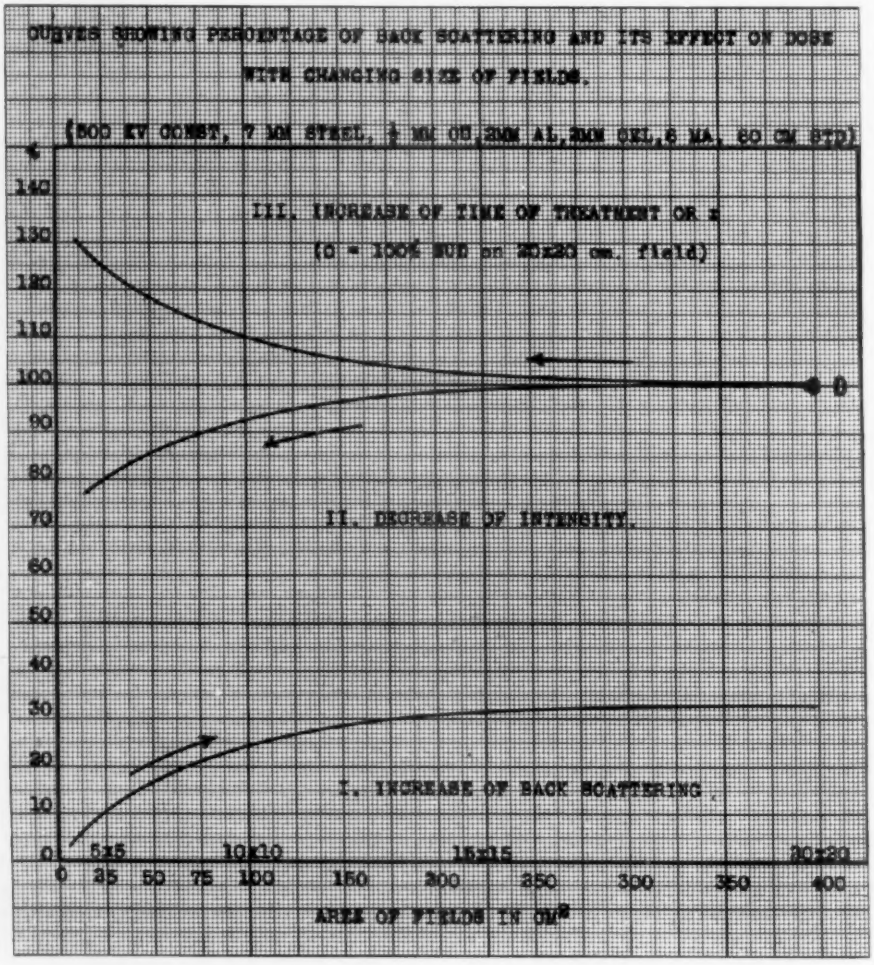
CURVES SHOWING PERCENTAGE OF BACK SCATTERING AND ITS EFFECT ON DOSE
WITH CHANGING SIZE OF FIELDS.
(500 KV CONST, 7 MM STEEL, ½ MM CU 2MM AL, 2MM GEL, 6 MA, 60 CM STD)
III. INCREASE OF TIME OF TREATMENT OR E
(O = 100% HVE on 20x20 cm. field)
II. DECREASE OF INTENSITY.
I. INCREASE OF BACK SCATTERING.
5x5
10x10
15x15
20x20
AREE OF FIELDS IN CM²

FIG. 15. Effect of variation of size of fields on percentage back-scattering at 500 kv. constant.

electrical conditions differs so greatly in various installations that the switchboard reading conveys a very rough idea at best. Even for the control of steadiness of an apparatus operating under well-known conditions, the milliamperage reading must be used with exceedingly great care and only in conjunction with a check-up ionization chamber, which must be kept permanently

tempting to evaluate physically how much of a given quantity of radiation is absorbed in the form of energy in the human body, some very great difficulties are encountered. First of all, the beam of even the most homogeneous radiation used in roentgen therapy comprises rays spread over such a wide range of wave lengths that it is practically impossible to arrive at

precise laws for their absorption. Then, as Quimby and McNattin[35] have shown, there is a change in quality in the way of softening of every radiation which traverses a light atomic medium, as, for example, the human body, the change increasing with depth and size of fields; and, finally, the mechanism of absorption itself be admitted, however, that so far the efforts in this direction have remained impractical. Very recently Lauritsen[22,23] overcame the difficulty to some extent, joining, on the basis of certain practical assumptions, the relation which exists between the quality (equivalent voltage) and quantity (r) of a given roentgen beam, through

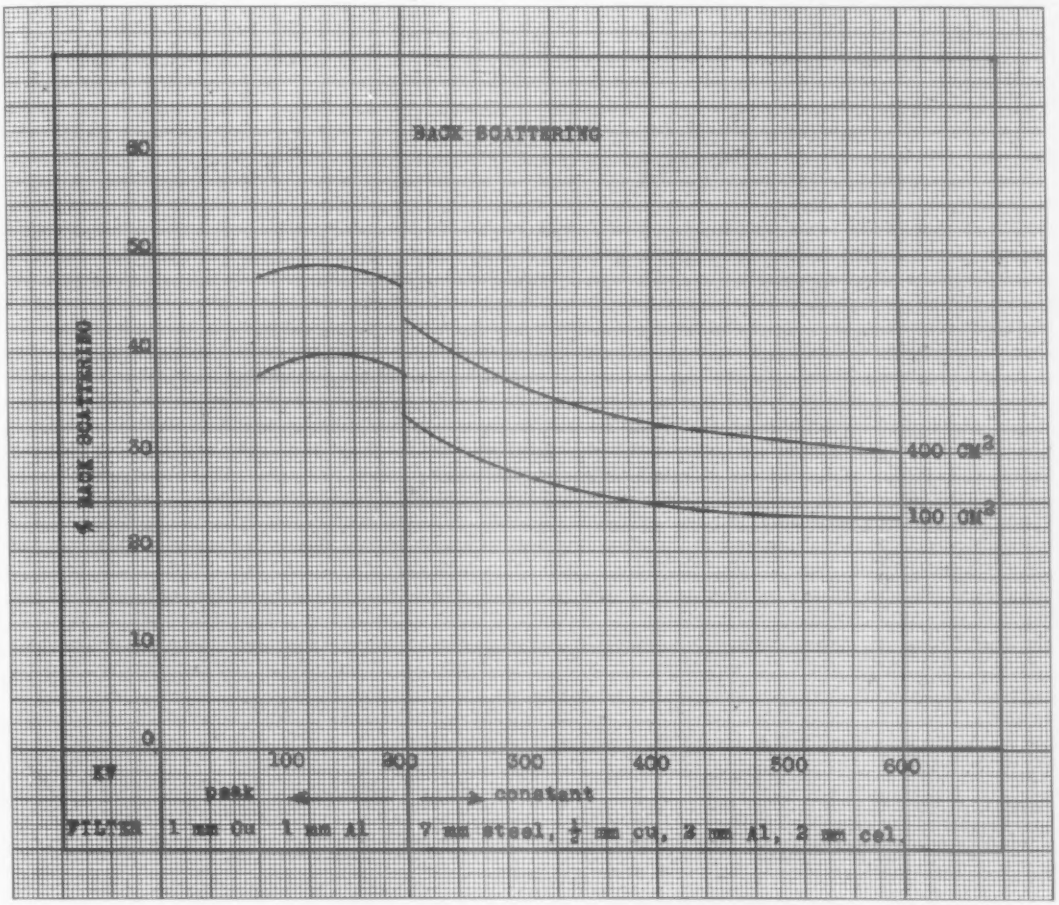

Fig. 16. Decrease of percentage back-scattering with increasing voltages.

is manifold. It was suggested that to eliminate all the above inconveniences, the absorption alone be considered, on the assumption that equal amounts of energy absorbed produce an equal effect. This led to repeated endeavors to express the roentgen dose administered to a patient in unit of energy absorbed, that is, in ergs, instead of roentgens, some standard medium being used for the purpose of comparison. It must the intermediary of energy absorption, with that of the biological dosage. This very interesting procedure will be dealt with in detail later, when discussing the biological dosage.

If, thus, the problem of energy absorption determinations cannot be solved for the present by direct physical measurements, there are certain indirect methods which permit the evaluation of absorption

conditions from a study of the distribution of the radiation within an irradiated volume of the human body. At least two of these methods are of unquestionable practical importance: (*a*) the determination of the percentage depth dose and (*b*) the estimation of the surface back-scattering. Both of these have the additional advantage that they make use of relative measurements, the error which may exist in the realization of the roentgen for higher voltages thus falling away entirely. (*a*) The percentage depth dose, as is well known, represents the ratio of the roentgen intensity as measured at a given depth (usually at 10 cm. = D_{10}) of the absorbing body to the intensity as measured on the surface of the body. Its magnitude is influenced by three main factors: the skin target distance, the amount of absorption and the amount of scattering. Concerning the first it may be said, as Lauritsen[23] pointed out, that it has no bearing on the amount of energy delivered at a given depth, except that it determines the size of volume to be irradiated; the second and third are sequences of the interaction of the absorbing medium and of the acting beam. The change in size of fields produces a variation in the amount of scattering and hence may be considered a function of this. A great deal of work has been done in determining the percentage depth dose values up to 200 kv., as used in deep roentgen therapy, and one may affirm now that this problem has been solved quite satisfactorily. The value at D_{10} rises in large fields as high as 40 to 50 per cent. More recently through the effects of Rees and Clark,[36] of Mayneord,[27] and others, some very accurate figures were also published concerning the equivalent* percentage dose of the gamma rays of radium, D_{10} equivalent being from 60 to 70 per cent. Obviously the D_{10} for the roentgen rays filling the gap between 200 kv. and the gamma rays of radium must possess

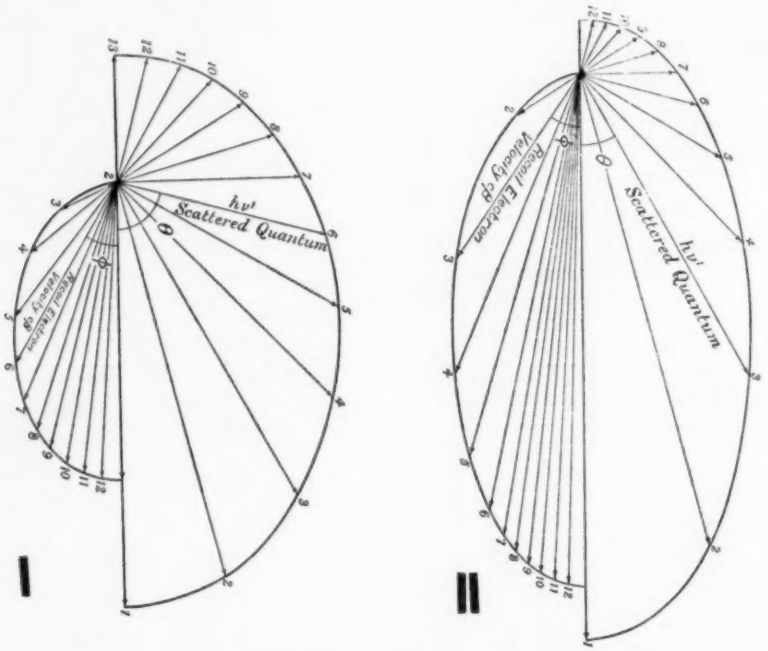

FIG. 17. Diagrammatic representation (after Rutherford, Chadwick and Ellis[39]) of the relations between the energies of the scattered quantum and the recoil electrons (shown by the lengths of the radius vector) for various angles of scattering. I, $h\nu' = 650$ kv. and II, $h\nu' = 2{,}550$ kv.

* "Equivalent" refers to the same skin target distance and same size field as employed in current deep roentgen therapy.

values which lie between 40 and 70 per cent. Indeed, measurements made by the various investigators[26,28,51] have confirmed this with the exception of one or two.[46] Our own measurements were carried up to 500 kv. equivalent and are in harmony with the others (Figs. 13 and 14). It was observed, however, that at least in two respects there was some deviation from the old isodose curves as measured for 200 kv. First, in the superficial layers, as for example D_5, the percentage depth dose remained rather close to that of 200 kv., in spite of the increasing voltages (Fig. 14) and second, by decreasing the size of the fields below 400 cm.^{2} a relatively larger D_{10} value was obtained with increasing voltage (Figs. 13 and 14). (*b*) The backscattering is important, as we shall see later, when estimating the erythema dose. In measuring its magnitude we found that the variation due to change of size of fields is of the same degree at the higher voltage (Fig. 15) as found at 200 kv., but that its amount decreases with increasing voltages (Fig. 16), the curve having a maximum value below 100 kv. equivalent, yet being quite pronounced in the range of deep roentgen therapy and then slowly decreasing.

The explanation of the above phenomena in connection with the change in distribution of the percentage depth dose and backscattering with higher voltages is not an easy one. Perhaps a better insight may be gained by considering, at this point, the two processes which according to our present knowledge mainly govern the absorption: the photo-electric and the scattering process. The photo-electric process was observed before the discovery of roentgen rays in connection with the hertzian rays and since then with all types of rays, such as ultraviolet, roentgen, gamma and cosmic rays. It consists in the fact that atoms when struck by radiant energy emit slowly moving electrons, which, to indicate the mode of production, are called photo-electrons. Numerous investigators have proved that the process is a function of absorption of the radiation: whenever an individual quantum is stopped by the mass of the atom, the whole energy of the quantum is absorbed by the atom, being converted into liberation of photo-electrons. In the range of roentgen rays, with which we are concerned, the photo-electric absorption is greatest for the light elements (Al) and the tissues of the human body at about 60 kv. equivalent; for the heavier elements (Cu, Pb) it is higher. For the same reason, aluminum forms, as already mentioned, a very suitable material for half-value layer determination in the higher voltage field, where its photo-electric absorption is nil and the entire attenuation is due to scattering, whereas copper carries a certain amount of experimental error. The second process, that is, the scattering process, in its early stage was based on the theory that roentgen rays are electromagnetic waves. It was assumed that when such an electromagnetic wave traverses matter, each electron in the matter is set in motion in the same way, as, for example, the sound waves of a gun shot off at the edge of a forest set in motion all the leaves of the trees, and that due to this motion the electrons themselves emit scattered waves, as the leaves of the trees cause sound to be scattered—in the form of an echo—in all directions. In this form, the scattered rays were assumed to possess the same wave length as the primary incident beam just the same as the echo is of the same pitch as the original sound. Very soon, however, it was found that this is not the case. In fact, it became more and more apparent that a softening of the rays occurs in the process of scattering. In 1922, Compton[6] finally demonstrated by means of spectroscopic analysis that the scattered rays are of longer wave length than are the incident rays which produce them, and from this he elaborated the theory which is now universally known as the Compton effect. A primary postulate of this theory is that the roentgen rays and, for that matter, all electromagnetic vibrations, are not waves but minute particles, or quanta, so-

called photons, shot, in the form of concentrated bundles of energy, with tremendous speed from their source. If such a quantum strikes the electron of an atom, with such a force that it cannot be absorbed (in the photo-electric effect the quantum is absorbed), the collision may be compared to that of a golf ball striking a perfectly elastic football. If the impact is straight, the football will move forward and the golf ball will bounce back, but at any other angle, the football will recoil and the golf ball will shoot off at an angle with less momentum than it had when it struck. In a like way, each electron recoils when it scatters a quantum of roentgen rays removing some of the energy of the quantum and hence lowering its frequency (lengthening its wave length or degrading its quality). The direction of the recoil electrons is a function of the angle under which the quantum bounces off, and the range is the result of the force with which the incident quantum strikes and of the firmness with which the electron is bound in the atomic structure (Fig. 17). Clearly, in the roentgen rays with which we are concerned the recoil electrons have a greater forward direction and range and are more numerous, the higher the voltage applied. It may be said, in this respect, that above 100 kv. equivalent, the bulk of the absorption in human tissue is represented by the formation of recoil electrons. Of course, there remains a certain scattering without change in wave length, due to the collision of incident quanta with very tightly bound electrons, but the amount of this becomes progressively less as the voltage increases.

When Compton[6] presented his theory before the Radiological Society of North America in June, 1924, he also included some photographs obtained by Wilson with the cloud expansion method. We are reproducing these photographs (Fig. 18) because they demonstrate better than anything else the difference between photo-electrons and recoil electrons. In I, very soft roentgen rays were used. One may note in the path of the roentgen beam four rather long tracks of photo-electrons and three spheres representing short range recoil electrons. In II, the rays were a little harder. Here the recoil electrons are more numerous, their tracks are longer and most of them show "tails" or, as Wilson calls them, "fish-tracks," the heads always pointing toward the roentgen source. Finally, in III, the rays were hardest. Here one sees only recoil electrons, some having longer and others shorter tracks, according to whether they move forward or at an angle with the incident beam. Of course, with further increase of the hardness of the rays, still longer tracks are obtained, so that the gamma rays of radium, for example, produce recoil electrons the tracks of which measure in air at atmospheric pressure from 1 to 4 meters.

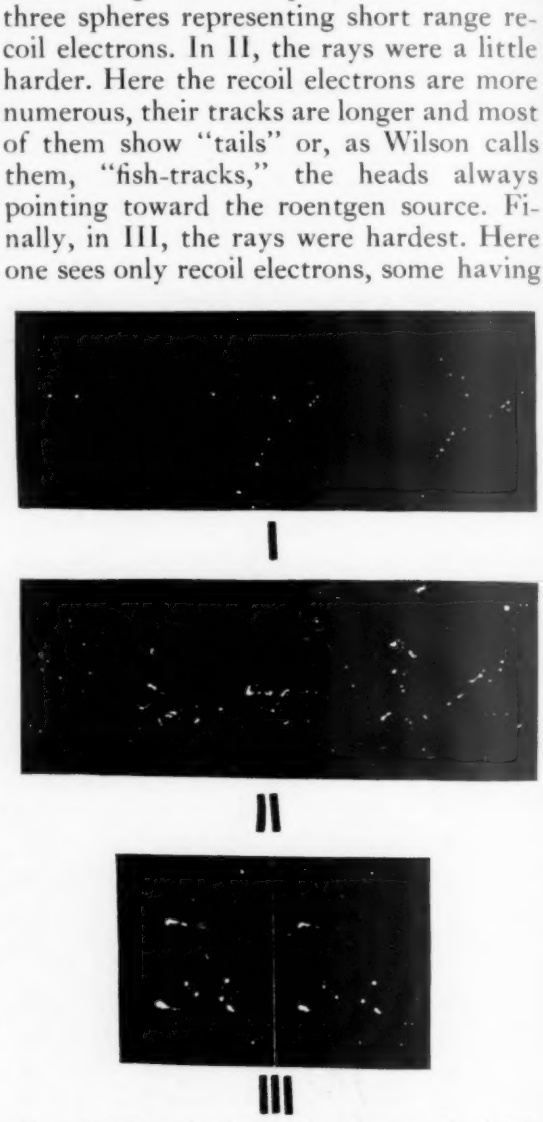

FIG. 18. Wilson cloud expansion photographs showing difference between photo-electrons and recoil electrons. I, very soft; II, medium and III, hard roentgen rays. (Reproduced with permission from *Radiology*.[6])

In returning to our subject, we may say the following in connection with the percentage depth dose and back-scattering distribution. The absorption of the roentgen rays of lower voltages in the human body leads, as already stated, principally to the production of photo-electrons. Above 100 kv. equivalent, the Compton effect assumes an increasingly prominent part, and the higher the voltages, the greater the number and forward range of the recoil electrons. The falling away of the photo-electric effect leads to less attenuation of the primary beam in the superficial layers, whereas the increase in the Compton effect insures a more uniform distribution with less back-scattering of the radiation throughout the irradiated volume. D_{10} will show a progressive increase in value (Fig. 13) which in the smaller fields will assume also a relative increase and D_5 (Fig. 14) as well as the surface back-scattering (Fig. 16) will appear relatively smaller when compared to the values of 200 kv. Of course, the heterogeneity of the primary beam and especially the variation of its attenuation along the path due to the multiple Compton shifting (formation of secondary, tertiary, etc., recoil electrons) and the ultimate photo-electric absorption of part of the degraded radiation, will produce an influence in several ways, but this variation, as a whole, will rather add than detract from the above values.

We may also mention here that as very recent investigations have shown, radiations, when striking an atom, liberate, in addition to the negatively charged photo- or recoil electrons, also a positively charged particle, the so-called positron, which, however, because of its easy disintegration, is extremely difficult to demonstrate.

It is possible, even probable, that roentgen rays have a similar effect in the process of absorption in the human body and that anticipating further increase of the voltage range, positrons may assume a practical importance which cannot be neglected.

B. *Biological effect.*

(1) Dependence on quality. A very voluminous literature has been written on the question of dependence of the biological effect on the quality of the radiation given, but notwithstanding this, the problem still appears nearly hopelessly entangled in the realm of empirical argumentations. Some investigators believe that the biological effect is purely a function of the physical quantity of the radiation administered, assuming that equal quantities (equal number of roentgens) produce an equal effect regardless of the quality; others, more cautiously, make the amount of energy absorbed the responsible factor, stating that equal physical energies absorbed produce an equal effect and still others are of the view that, in addition to the factor of energy absorption, there is also a direct dependence on the quality of the radiation. We will try to consider the problem in the light of some new experiences gained in connection with the application of higher voltage roentgen rays. In doing so, some enlightenment may result by first differentiating between the "selective" and "differential" biological effect. These were defined by Russ and Scott[38] as follows: A "selective" action of an irradiation occurs when a beam in passing through a collection of cells causes some varieties to be more affected than others, quite irrespective of the variation in the intensity of the irradiation as it goes from one point to another or from plane to plane, whereas the "differential" action occurs when different biological effects take place in any particular tissue after exposure to radiation of different wave lengths, although the actual amount of energy liberated in the tissues is the same. Clearly the first refers to tissue sensitivity and one may expect little or no change here from the introduction of higher voltages. Indeed, observing the action up to 500 kv. equivalent, we have noticed no difference in the established laws governing the radiation response of the various tissues, the cells of a lymphosarcoma, for example, continuing to melt

away as rapidly as with the 200 kv. radiation and the cells of some adult tumors remaining as refractory as before. It seems, in this respect, that there is no quality dependence. But with the differential effect, it is another matter. Former experimental evidence,[10,38] and especially clinical observations, by comparing the 200 kv. radiation with the gamma rays of radium, showed that there is a proportionately greater biological effect with decreasing wave length. In extending the investigations to 700 kv. (induction coil type) Failla and his coworkers[46] found that with wheat seedlings, *Drosophila* eggs and mouse tails, taken by themselves, there is no differential action of radiation with respect to wave length, but that in considering the skin erythema and other clinical phenomena, there is a very marked difference in the above sense. We have experienced the same thing with rays up to 500 kv. equivalent, mouse tails showing no wave length dependence whereas deep-seated tumors, which were influenced only moderately with the 200 kv. radiation, were made to disappear promptly with the 500 kv. equivalent radiation. In coördinating these observations with the absorption measurements, as stated in the former paragraphs, we may perhaps venture the following explanation: In simple biological media, as, for example, wheat seedlings, *Drosophila* eggs, mouse tails, etc., the absorption conditions are very much like those in air and therefore it is only natural that here the same amount of radiation delivered, as measured in roentgens, that is, under identical or nearly identical conditions, should produce the same biological effect, regardless of the change in wave length. However, if the medium is complex, as, for example, the human body, a great deal of variation may be expected. The gradual diminishing of the photo-electric effect and the increase in the number and range of the Compton electrons, on the one side, and the change of the scattering process and modification of the distribution of the radiation throughout the irradiated volume, on the other, are functions which depend among others on the wave length of the primary beam. Since we are unable to measure properly the amount of energy absorbed, except in terms of roentgens, we cannot state definitely whether the increased biological effect inherent in higher voltages is a result of increased absorption or of a differential effect. But we may state that, in either case, the variation in the wave length is the all important factor which has brought about this effect. Thus, while we may not be capable of proving with our present methods that there is a differential action of the rays depending directly on the wave length, we must at least admit that there is an indirect dependence, which means that the quality of the radiation plays a great part in determining the quantity of radiation (number of roentgens) which must be administered in a given case. This, then, brings us up to the point of biological dosage.

(2) Biological dosage. For a long time attempts have been made to find some sort of biological indicator which would permit the accurate conversion of physical data as measured in a laboratory into biological effect as observed on a patient. It was felt that physical units, although very precise under rigid conditions and the circumstances under which they are measured, do not and cannot express phenomena which occur in the application of the radiation to a mass of living tissue. However, for reasons which have already been mentioned in discussing the quality effect in various media, and for other reasons, so far all efforts have remained fruitless. The clinical radiologist, therefore, must continue to determine his own biological dosage on the basis of certain reactions which he notices on the patient, but he should exercise care by coördinating his observations with available physical data which he then must use for the stabilization of the radiation output in that particular instance. There are especially two biological reactions which may serve as guiding points in this respect: (*a*) the skin erythema and

(*b*) the reaction of the tissues around the irradiated tumor.

(*a*) Skin erythema. It appears superfluous to reopen here the discussion concerning the many advantages and still more disadvantages attributed to the skin erythema as a unit of dosage, and thus to revive certain prejudices which have been formed around this most heatedly debated problem in the science of radiology. The fact remains that until a satisfactory method is devised for the measuring at the point of action of the amount of energy absorbed per cubic centimeter of tissue, which must be the ultimate goal of physical measurements, the skin erythema will continue to be used in clinical therapy as a unit of measurement. Lauritsen[22,23] recently succeeded in bridging over the gap between the physical and biological dose in a very ingenious manner. He proceeded by converting the "roentgen" unit of quantity into the "erg" unit of energy and calculated the actual energy in ergs per cm.^{2} for a quantity of radiation equal to 1 roentgen. On the basis of certain assumptions which cannot be justified theoretically, but which agree well with practical observations, he then determined the number of ergs (1.4×10^4 ergs) absorbed per cm.^{2} of the skin to produce an erythema (in the voltage ranges known). Finally, by using water as absorbing medium, he calculated the number of roentgens necessary to produce at any wave length the absorption of an equal number of ergs (1.4×10^4 ergs) per cm.^{2} of a surface layer 1 mm. thick. The result of this procedure was that he was able to plot in the form of a curve (Fig. 19) the number of roentgens, that is, the physical quantity of the radiation, which must be delivered to the skin to produce an erythema, that is, the biological effect, for the range of voltages from 20 to 2,200 kv., large fields of exposure being used. As one may note, such a solution of the problem does away with many of the so-called "peculiarities" of the skin erythema dose. To take one example: It was hitherto thought impossible to explain why, for instance, 600 r produces an erythema at 200 kv. peak, whereas with radium one must administer more than three times as much (in the neighborhood of 1,600 to 2,000 r) to obtain the same

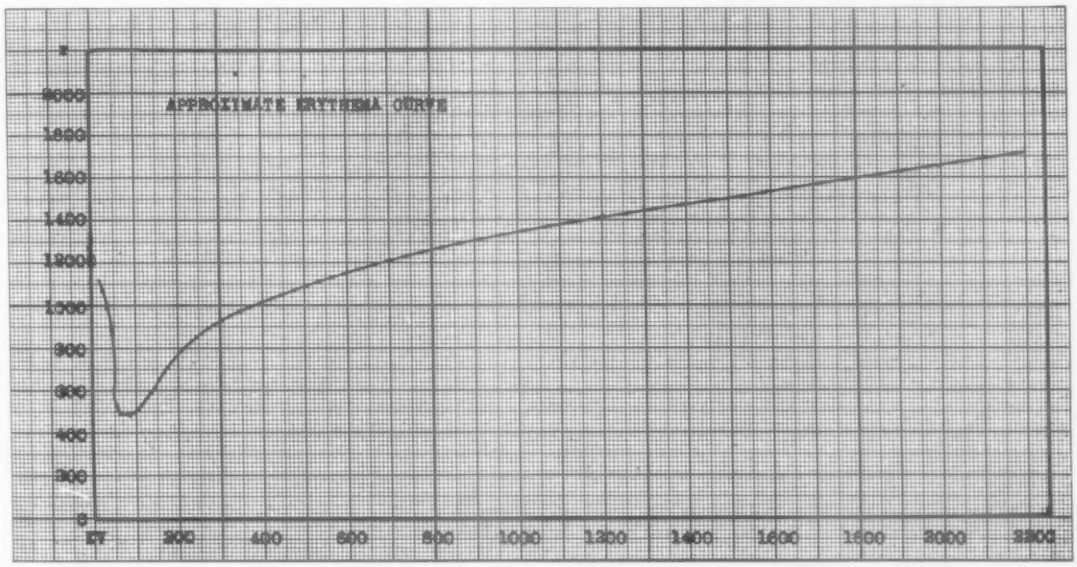

Fig. 19. Calculated curve of Lauritsen, indicating total number of roentgens required to cause absorption of 1.4×10^4 ergs per cm.^{2} of a surface layer of water 1 mm. thick. This should be approximately equal to an erythema dose; kv. expressed in equivalent voltage.

erythema. A "peculiar" dependence of the skin on the wave length was blamed for the difference. In the light of the above calculations, we now see that the variation is the result of a change in the scattering and mechanism of absorption of the radiation, and that, because of this, a proportionately larger amount of total energy must be delivered to produce an erythema with the gamma rays of radium.

In a series of over 100 cases, we have experimentally observed the erythema for voltages up to 500 kv. (equivalent). The number of roentgens which were required to produce it harmonizes very well with the calculated figures of Lauritsen. In many instances, to obviate a possible error due to faulty reading of the instruments at higher voltages, we measured the time element which was necessary to produce the erythema at a given voltage and calculated the number of roentgens indirectly from comparison with the 200 kv. apparatus, where the measuring instrument could be used safely. We may state that the level of the erythema was taken in the sense defined by Glasser and Portmann[14] and not in the form of a "threshold," as used by Duffy, McNattin, Copeland and Quimby.[46] The variations in the erythema due to back-scattering, when changing the size of fields, were calculated according to the curves shown in Figures 15 and 16, and they gave a fair approximation to reality. Perhaps we should also mention that there seems to be some difference of appearance in the erythema at higher voltages, a desquamation of the skin, for example, occurring at lower levels than with 200 kv. but this problem must be reserved for further investigation.

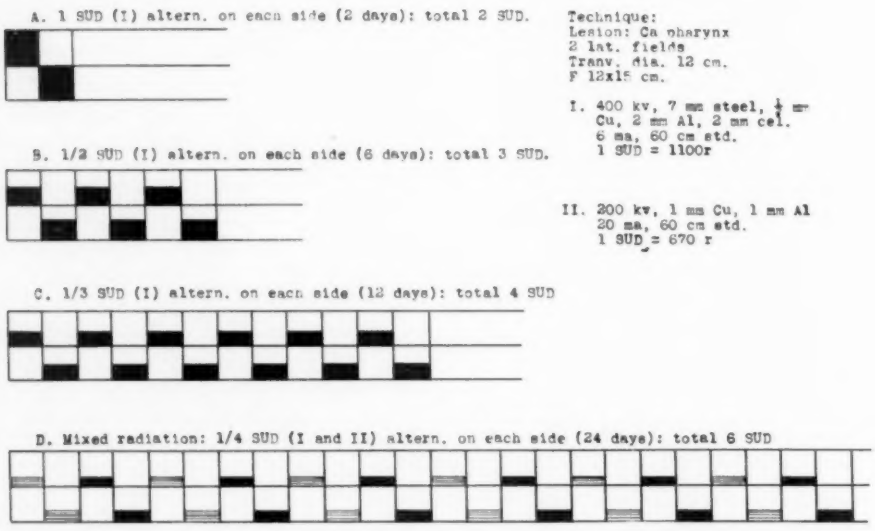
BIOLOGIC REACTION: 2-FIELD CROSSFIRING
A. 1 SUD (I) altern. on each side (2 days): total 2 SUD.
B. 1/2 SUD (I) altern. on each side (6 days): total 3 SUD.
C. 1/3 SUD (I) altern. on each side (12 days): total 4 SUD
D. Mixed radiation: 1/4 SUD (I and II) altern. on each side (24 days): total 6 SUD
Technique:
Lesion: Ca pharynx
2 lat. fields
Transv. dia. 12 cm.
F 12x15 cm.
I. 400 kv, 7 mm steel, ½ mm Cu, 2 mm Al, 2 mm cel.
6 ma, 60 cm std.
1 SUD = 1100r
II. 200 kv, 1 mm Cu, 1 mm Al
20 ma, 60 cm std.
1 SUD = 670 r

FIG. 20. Various methods of irradiation to obtain an approximately equal biological reaction with two opposite fields of cross-firing.

(b) Deep-seated reaction (mucositis). Whereas the erythema, with all its inconveniences, serves in the form of the above definition, as a good biological indicator of the effect of a certain quantity of radiation on the skin and on the tissue layers immediately beneath it, the effect on a deep-seated lesion can be studied only on the basis of a more complex clinical observation. There are two locations in which the degree of the biological effect on a

deep tumor, principally in case of cross-firing, may be judged fairly accurately from the reaction produced on the structures of the neighborhood, such as the mucosa of the surrounding cavities and organs: the neck with the posterior oral cavity, pharynx and larynx, and the pelvis with the vagina, rectum and bladder. Figure 20 shows, for example, the irradiation of a carcinoma of the upper pharynx by four different methods extending from the single exposure method to the fractionated protracted Coutard method with mixed radiation. As is noted, the amount of radiation varied from 1 erythema dose per field if given at one sitting, to 3 erythema doses per field if spread over twenty-four days, the cross-diameter being only 12 cm. and two fields (lateral) being used for the purpose of cross-firing. Under these conditions, we observed the following reactions of the tissues in the neighborhood of the tumor: in all instances, a reddening of the mucosa of the oral cavity and pharynx appeared within four or five days if the treatment was given at one sitting, and within twelve or fifteen days if the Coutard method was used; in the remaining, reddening occurred between the two intervals. Within a few days after the reddening a white fibrinous membrane formed throughout the mucosa. In the case in which the dosage was heavier, this membrane became quite thick and after removal it produced bleeding as in diphtheria. It is interesting that the reaction of the skin of the face or neck always appeared after the mucositis was well developed, consisting of simple erythema in the lighter irradiations and of erythema with desquamation in the heavier irradiations. The mucositis subsided first, the reaction being completed within three to four weeks, whereas the skin change lasted considerably longer. Clinically the patient developed, during the period of mucositis, sore throat, burning sensation, difficulty of swallowing and a very marked dryness of the mouth, this latter lasting to a lesser degree for several months. A second example is the irradiation of a carcinoma of the pelvis (cervix) with the same methods, two fields (anterior and posterior) being used for the purpose of cross-firing. Here, too, a mucositis developed at the intervals stated above and the skin erythema appeared later. The mucositis manifested itself clinically in the form of diarrhea, marked injection of the vagina with increased discharge and, when heavier irradiations were applied, in the form of bladder symptoms. In the cases in which additional radium was placed intravaginally, a diphtheric membrane formed around the site of the radium, resulting eventually in atresia of the cervix or even the entire upper vagina. In using the degree of these reactions as a comparative criterium and assuming that 110 to 120 per cent of a skin erythema dose—in the process of cross-firing—is the lower limit of a mucositis which manifests itself in the above clinical symptoms, we were able to estimate the biological dosage at various depths. By converting this dosage into a physical dosage as measured in phantoms with various media (water, rice, paraffin, etc.), we found that there is a very close harmony between the two, indicating that the above figures represent, under the conditions specified, fairly approximate values which may be used with safety in practice.

C. *Clinical application.*

(1) Indications. If roentgen therapy with extremely high voltages seems feasible from the physical and biological standpoint, the question arises whether it is also indicated from the clinical standpoint. As already mentioned in the introductory remarks, the idea that 200 kv. therapy embodies the advantage of roentgen irradiation, as a whole, to such a high degree that nothing more, or very little, could be added from its extension beyond that point, seems to have gained much ground. Yet, if we analyze the subject from the point of view of what has been said in the preceding paragraphs, we will find that there

are three things in particular which are worthy of consideration: first, the increase of the differential action of the radiation with increasing voltages. It was evolved in paragraph B, 1, that this action is the result of better scattering and absorption characteristic of the more penetrating rays. But whether or not the effect is an indirect one, or depends on the selective function of the wave length, the fact remains that, in practice, it permits the administration of a proportionately larger amount of radiation with increasing voltages. Second, the increase of the total energy which can be delivered to obtain an erythema with increasing voltages. This is a natural sequence of the first. We find, for example, that if 600 r, measured on the surface of the skin, produces an erythema with 200 kv. peak (154 kv. equivalent) 1,200 r may be administered at 700 kv. equivalent and over 1,800 r with gamma rays of radium, to produce the same erythema. In deep-seated tumors, because of the somewhat better distribution of this radiation, the ratio of energy increase may assume an even more favorable aspect. That such an increase must have a beneficial effect in all radiosensitive tumors difficult to reach by the former (200 kv.) method need not be stressed further. It would be, indeed, most unusual if it were not so. But this, then, also indicates that the procedure of expressing the dose of a radiation in a given number of roentgens (e.g. 600 r) for all qualities of radiations, by assuming that an equal number of roentgens leads to the same biological effect would lead to a most unfortunate confusion in the practical application of radiation therapy. Presented in such a way, the erythema dose is undoubtedly the more preferable for the time being for clinical purposes. Third, the increase of the depth dose with increasing voltages. This serves to further improve the absorption conditions, and thus the biological action, with increasing hardness of the rays.

(2) Clinical response and immediate results. Because of the above difference in action, we may expect that the use of higher voltages will have at least two advantages in the treatment of malignant tumors as compared to the 200 kv. radiation: It will lead to the delivery of a larger amount of radiation to the deep-seated tumors with less injury to the skin and overlying tissues, and it will permit a more uniform irradiation of the tumor as a whole. Indeed, we have found that tumors which because of difficult cross-firing conditions could not be influenced satisfactorily by irradiation with 200 kv., as, for example, malignancies of the oral cavity, pharynx, or larynx, metastatic carcinoma of the glands of the neck, carcinoma of the pelvic organs, etc., were made to disappear promptly following the use of higher voltages (400 to 500 kv. equivalent) and that the skin or other surrounding structures were affected decidedly less than is customary. Another advantage of technical importance is the fact that cross-firing is markedly simplified, a smaller number of portals being necessary to produce the desired effect.

We may add, however, that as great as these advantages are from the point of view of improvement of the biological action of the rays and the clinical response of the individual tumor, the group of neoplasms, as a whole, continues to be governed by the same general laws of radiosensitivity as formerly. Highly sensitive tumors respond readily whereas the recalcitrant tumors, although they may show some degree of improvement in their response, in the main continue to remain untractable also with the higher voltages. And, as to quoad vitam, the clinical extension of the malignancy at the time of treatment still remains the supreme deciding factor. Every irradiation acting more or less as a local agent, although in a considerably broader sense than an operation, will fail to bring about a control of the malignant process whenever a widespread generalization has already taken place. For this reason, super-high voltage roentgen therapy, while it may be expected to lead

to decided improvement in the end-results of many, especially deep-seated, malignancies[29] by bridging the gap between the 200 kv. and the gamma rays of radium, will not prove a panacea for the cancer problem as a whole.

SUMMARY AND CONCLUSIONS

The purpose of this paper is to present in general outline the recent contributions to the advancement of the roentgen therapeutic armamentarium by increasing the voltage above 200 kv. The subject is discussed from the point of view of technical development as well as of physical, biological and clinical application of the radiation produced. The first entails the consideration of certain major points of tube design and of many rather complex problems of engineering of electrical plants; the second requires the close coördination of laboratory measurements with phenomena observed in living tissues. In extending the voltage range to fill the gap between the so-called deep roentgen therapy and the gamma rays of radium, certain regularities are noted which permit the establishment of curves indicating rather clearly the relation between the physical dose measured in roentgens and the biological dose expressed, for example, in erythema or skin unit dose. It is proposed that, in practice, the following procedure be pursued in prescribing the irradiation in a given case: The quality of the radiation is expressed in equivalent volts which is read from the curve in Figure 12 after determining, under the precautions indicated, the half-value layer in water or aluminum with the tube operated at the desired voltage and the filter in place. The dose is prescribed in terms of a skin erythema or skin unit dose, the number of roentgens which is necessary to produce that erythema at any particular equivalent voltage being read from the curve in Figure 19. The total amount of radiation which must be given to a tumor or lesion is then determined—in percentage of a skin unit dose—by the usual cross-firing procedures, by taking into consideration the range of the equivalent voltage used, the depth dose at the level of the tumor and the amount of back-scattering on the surface of the skin with various sizes of fields. In case mixed radiation is used, which we believe to be of decided advantage, the individual dose for each type of radiation is calculated separately in terms of percentage of a skin unit dose for that particular equivalent voltage and the individual fractions added to make up the total dose. It is realized, of course, that the values so obtained may only be approximate and that further observations may to some extent change the shape of the curves here included, but it is felt that at the present time, and until some sort of an energy absorption unit is introduced, this procedure is the simplest and, most important of all, the safest from the point of view of least damage to the normal structures. Perhaps it should be added that the curve relating the skin unit dose to the number of roentgens which are applied at various equivalent voltages to produce it is recommended only as a starting point and that the precise values for every particular instance must be determined on the basis of clinical findings from personal observation.

All in all, it appears clear from the foregoing that the advances of the last few years have contributed enormously to the betterment of practical radiation therapy. In a time of such rapid progress, however, it is inevitable that a certain confusion here and there should arise. Moreover, when we see, just now, light, and for that matter, any sort of radiation, including roentgen rays, converted by routine experimenters (Dirac, Oppenheimer, and others) into positrons and electrons, which are the bulwark of tangible matter, and when we observe the artificial production in large quantities of neutrons which penetrate the electrical defenses of an atom in a somewhat paradoxical or even mysterious way, does this not sound like an era of scientific poetry in which progress is made by leaps of imagination rather than

by the slow, rigorous procedures of reasoning? Clearly then, many phases of the nature and action of radiations in general and their therapeutic application in particular must await further more detailed investigations. For this reason, as Lauritsen, by whose recent work this paper was greatly inspired, so well expressed it, "radiology is still an art and probably will remain so for some time to come."

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Vol. XXXI, No. 5

A QUANTITATIVE METHOD FOR STUDYING THE ROENTGEN-RAY ABSORPTION OF TOOTH SLABS*

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ROCHESTER, NEW YORK

INTRODUCTION

AN ACCURATE, simple method of densitometric analysis of roentgenograms can be of great practical assistance in many fields of medicine. Study of the structure of thin tooth slabs by such a method in this laboratory has yielded data of considerable value with regard to normal and pathological tooth conditions.[1] A similar method, with suitable modification, might be adapted for the study of other parts of the body than the teeth. These studies must, of necessity, be restricted at first to the more opaque portions of the body. Problems of theoretical, as well as clinical, importance, such as an investigation of normal and pathological bone conditions, the sequence of events in the repair of fractures, the breaking down and healing of acutely diseased areas in bone, and a study of the deposit of heavy metals and other chemicals, may be attacked by this method. An accurate study of the changes brought about by the secretion or excretion of opaque media in certain soft tissue organs may also be feasible (Newell[2]). Measurements of the concentrations of solutions is possible, although the method here described is too cumbersome, as yet, to make this practicable.

The greatest handicaps in clinical roentgen densitometry are presented (1) by the non-uniformity of the material to be studied, i.e., the variation from animal to animal, and especially from person to person; (2) by the difficulty of obtaining identical positions and identical technique in repetitions of the roentgenograms for comparative studies upon the same subject, and (3) by the lack of a suitable standard by means of which comparative values may be obtained on different films, independent of film properties—physical or photographic. The use of thin tooth slabs for roentgen densitometry has, for the first time, given a suitable material with which to overcome the second and third handicaps mentioned above, and to a great extent, because of the uniform thickness and absence of superimposed soft tissue, has made possible the study of the first, i.e., the non-uniformity of the material. By the use of a thin tooth slab which may be roentgenographed at will, the limits of accuracy and reproducibility of the method may be measured quantitatively, an achievement which has not been possible in living material.

Identical roentgenograms of a tooth slab, when measured by a densitometer, give varying results due to the differences in thickness of the emulsion, grain size, etc., of the different films. It was therefore suggested by R. B. Wilsey, of the Eastman Kodak Company, that a simultaneously exposed material might be used as a standard of comparison, because then any variation in the emulsion properties would give relatively the same variation in blackening under the standard substance. The absorption of a given portion of a tooth slab, as measured on the film by the densitometer and expressed in exactly the thickness of aluminum necessary to give an equivalent absorption, provides an adsorption measurement that has been found to have a fairly high degree of precision.

The use of a metal penetrometer as a standard was suggested first by Roentgen, who attempted to find a law relating transparency to thickness. Penetrometers have

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since been used for a diversity of purposes, principally, however, to describe the hardness of a roentgen-ray beam for roentgenographic or therapeutic work. No one, as far as we have been able to determine, has used a penetrometer to obtain quantitative interpolated values expressing the relative absorption of body tissues. A previous study by two of us (F.W.B. and S.L.W.[3]) expressed the relative absorption of certain body tissues in terms of photographic density of the tissue image. Klein[4] made a study of comparative roentgen-ray absorption of rats' jaws and teeth, showing differences in absorption between normal rats and those fed on diets causing deficiency of calcific deposition. He used a lead sector disk to obtain a photographic density scale, and expressed the photographic density differences of the tissue images semi-quantitatively in percentages. He did not use a densitometer to measure the films. Scherbel[5] measured certain dental films with a densitometer in order to obtain an optimum exposure. However, he used no penetrometer as a standard. The combination of simultaneously exposing a penetrometer of suitable form and interpolating the densitometer readings in the film image of the tissue in terms of the corresponding thickness of the penetrometer is, in brief, the method, the details of which are described below. This method, therefore, entails the application of the principles of photographic sensitometry (as described by Jones,[6] Wilsey,[7] et al.) to the roentgenogram of a body tissue, in order to study the normal and pathological changes in body tissues—in this case a tooth slab.

Since the terms transparency, opacity and density are used in two senses in the study of roentgen radiation recorded by photographic emulsion, a definition and differentiation is given.

A. In photographic studies, the ratio of the quantity of light transmitted by a film area to the quantity incident on that area is said to be its transparency. The reciprocal of the transparency is the opacity. The density is defined as the logarithm of the opacity. Since the logarithm of a number increases when the number increases, the density increases when the opacity increases; in fact, the terms opacity and density are loosely used interchangeably.

B. In roentgenographic studies, the ratio of the amount of radiation transmitted by a material to the amount of radiation striking the surface of the material is said to be its radiolucency. The reciprocal of the radiolucency is the radiopacity, and the logarithm of the radiopacity is the density to roentgen radiation. Again, radiopacity and density are loosely used interchangeably.

Radiopaque areas in the tooth absorb more radiation and produce a film image of less density. Thus, when densitometer readings are made on the film images of radiolucent and radiopaque tooth substance, the readings are larger in the radiolucent areas. Hence, a higher densitometer reading corresponds to lesser radiopacity.

The densitometer readings are interpolated into their equivalent thickness of aluminum by means of the density-thickness curve (see Procedure). A greater thickness of aluminum absorbs more radiation and gives a film image of less photographic density. Therefore, larger interpolated values in millimeters of aluminum are found for more radiopaque areas.

MATERIALS

Several slabs of teeth, about 1 mm. thick, are obtained by slicing a tooth longitudinally through its center by means of two parallel, corundum-vulcanite disks on a No. 2 (watchmaker's) lathe made by E. W. Derbyshire Co., Waltham, Mass. These moist tooth slabs are then surface-ground plano-parallel, with an allowable variation of not more than ± 0.01 mm., by the Precision Optics Department of the Bausch and Lomb Optical Company.

The penetrometer used is made of 99.99 per cent pure cast aluminum supplied by the Aluminum Company of America. The penetrometer consists of two equal halves, each part being 15 mm. wide and 40 mm. long, having eight steps with a tread of 5 mm. depth. The steps were ground by the Bausch and Lomb

Company so that the first step is 0.25 mm. thick, each succeeding step being thicker by 0.25 mm. so that the eighth and thickest step is 2.00 mm. in thickness. The maximum variation in thickness of each step does not exceed ±0.01 mm. It is necessary that extreme care be taken in the machining of such a scale so that the tool does not catch and compress the aluminum, in which case a dense area will be produced which may be of designated thickness but of abnormal opacity to roentgen radiation.

The film used is a 5″×7″ duplitized roentgen film. It was found that the cardboard folder and other types of cassettes used for holding films in ordinary roentgenography absorb rays unevenly and may cause some scattering of the radiation after it has gone through the tooth. For this reason each film is wrapped in the black paper used to cover larger films in packing. This affords sufficient protection from exposure to light and absorbs a minimum of roentgen rays. The roentgen tube is a medium focus, 30 ma., air-cooled radiator type of Coolidge tube, energized by an oil-immersed, single valve, half-wave rectified equipment. Pieces of 16×20 cm. sheet lead are placed under the film, and are also used to mask off those parts not intended for exposure.

An enamel tray, 46×39×5 cm., a seven-clip dental film developing holder, a camel's hair brush 3 cm. wide, three quarts of Eastman roentgenographic developer, a Taylor bath thermometer, an Eastman interval timer, a tank of running water, a tank of Eastman roentgenographic fixing solution, and a dryer are used in the development procedure.

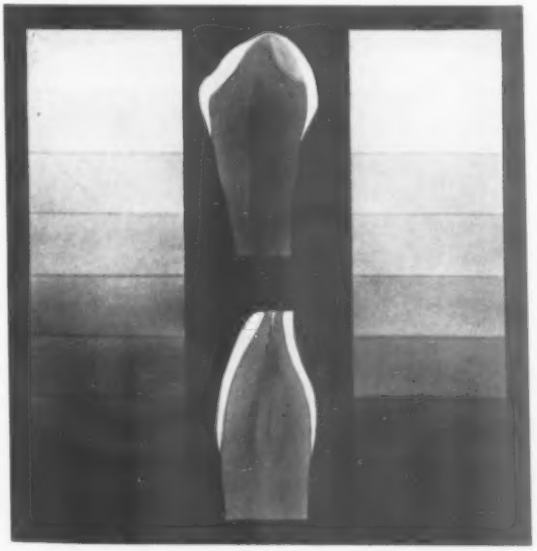

Fig. 1. Half tone reproduction of roentgenogram showing tooth No. 1 above and tooth No. 2 below, both between the two halves of the aluminum penetrometer. The thinnest steps of the penetrometer are at the bottom of the picture.

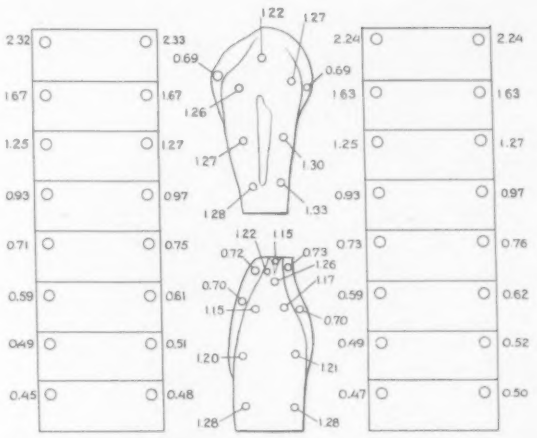

Fig. 2. Densitometer readings (absolute density units) in the various steps of the scale and in selected areas of the teeth images. Note low readings in the enamel image and high readings in the dentine image. The size of the circles indicates the relative size of the area measured in each densitometer reading.

PROCEDURE

The following detailed procedure indicates the minimum requirements for a practical method of obtaining interpolated values for dentine and enamel in equivalent thickness of aluminum with an error of less than 5 per cent.

A film is placed on a table beneath the roentgen tube. A piece of sheet lead is interposed between the film and the table top to prevent exposure to rays scattered by the table. One-half of the film is covered with another piece of sheet lead, and on the uncovered half, as near the center as possible, the tooth slabs are arranged around and between the two parts of the aluminum step tablet. The edge of the tooth specimens should be approximately 3 to 4 mm. from the edge of the scale to avoid possible errors due to the scattering of radiation in the aluminum. The roentgen tube is then centered over this half of the film, at a distance of 38 cm. above the surface. The aluminum filter should be removed from the tube stand, for any nonuniform material between the target and the film and specimens will cause an unequal dis-

FIG. 3. The Capstaff-Purdy densitometer with film in place for densitometer readings.

tribution of radiation striking the surface of the film, thus altering the density of the image. The exposure is then made for one second at 30 kv., 30 ma. The exposure data* should be checked before uncovering any part of the film to make sure that they are correct. The peak voltage should be checked by sphere gap readings. The specimens and lead are interchanged on the film, and the other half of the film exposed under the same conditions as the first. Two or more films are similarly exposed and developed at the same time.

The films are developed as soon as possible in fresh developer at a temperature of 65° F. for five minutes. The developing is done in a tray, and the films are brushed continuously, first on one side and then the other, with a camel's hair brush. At the end of five minutes they are fixed, washed, and placed in a special dryer, so constructed that no dust can collect on the surfaces.

After drying, the films (Fig. 1) are removed from their hangers and studied. Care in handling the film is essential so that errors due to scratches, abrasions, finger marks, and dust do not appear in the densitometer readings. Film density should be measured as soon after drying as possible to reduce this hazard. Two or more (usually ten) readings (Table 1) are made in each step on both halves of the penetrometer, each time placing the small circle in the opal glass of the densitometer* in the same relative place (Fig. 2), and keeping the eye-piece arm in the same position. The *average value* of the densitometer readings is obtained thus for each step, and plotted† as ordinates (Fig. 4) against the corresponding thickness of the aluminum steps in millimeters. By use of the spline and dogs, a smooth curve is drawn through these points, thereby giving interpolated values for *all densities* corresponding to *all thicknesses* of aluminum between the limits of the thinnest and thickest step. The various portions of the specimens are then explored, the densitometer readings obtained are interpolated from the curve for that film (Fig. 5), and the values thus found express the density of the specimens in terms of millimeters of aluminum. These density values in terms of millimeters of aluminum are tabulated (Table 1) and studied to determine the changes, if any, that occur in different parts of the specimen, or the variations from specimen to specimen.

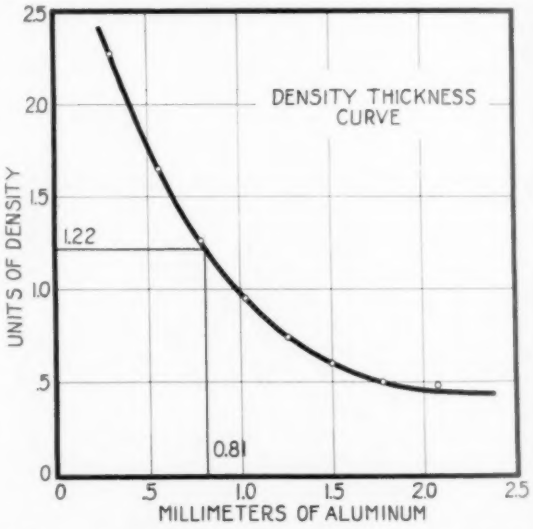

FIG. 4. Average densitometer readings (units of density) are plotted as ordinates, thickness of individual steps of penetrometer (millimeters of aluminum) as abscissae and a smooth curve is drawn using a spline. A densitometer reading of 1.22 density units from the dentine image is interpolated into its equivalent, namely 0.81 mm. of aluminum.

* Different tube and machine combinations give somewhat varying densities at the stated exposure conditions; a brief description of a simple method for obtaining optimum exposure conditions is included in the discussion.

* A Capstaff-Purdy densitometer (8), built and calibrated in density units (Fig. 3), is used to measure the density of the films.

† For plotting the data, blue-lined graph paper and a 4-foot celluloid draftsman's spline and dogs are used.

DATA

In the film presented as an example in the description of the procedure, the densitometer readings are noted to vary from a density of 2.28 under step 1 to 0.48 under step 8. This variation, as may be expected from the laws of radiation, is roughly logarithmic. The readings under the same thickness of aluminum vary from 2.33 to 2.24 under step 1, 1.63 to 1.67 under step 2, 1.25 to 1.27 under step 3, 0.93 to 0.97 under step 4, 0.71 to 0.76 under step 5, 0.59 to 0.62 under step 6, 0.49 to 0.52 under step 7, and 0.45 to 0.50 under step 8. Only a part of this seeming variation is real, since the densitometer is capable of repetition only to 0.02 density units in repeated readings of the same uniform area. Therefore, a given reading in any uniform area may be considered as precise to ±0.02 density units, with a standard deviation of ±0.01 (data to be presented later). The larger the number of readings obtained in a given area, the more accurate the average value will be. The variations in the same step may be attributed to a variety of factors, in which may be included film variations, graininess in the film, scratches, abrasions, etc. on the film, personal errors in observation, error in the densitometer, and inequalities in the penetrometer. Unfortunately, many of these errors are not subject to experimental study. However, all of the errors which are experimentally measurable have been studied by us (data to be presented later).

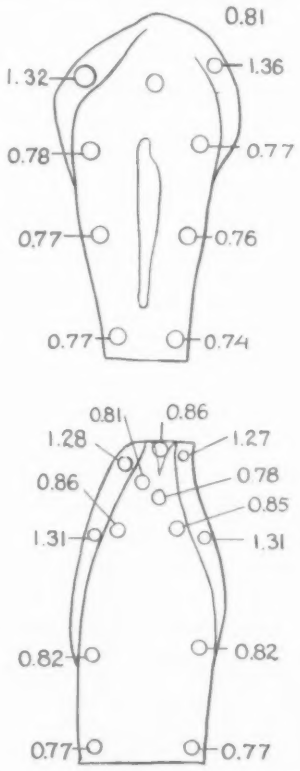

Fig. 5. Interpolated values in the enamel and dentine in terms of millimeters of aluminum. Note high values in enamel and low values in dentine.

Table I

ROENTGENOGRAM TAKEN 12/10/32
32 KV., 76 CM., 30 MA., 10 SEC.
NO FILTER, BLACK PAPER FILM COVERING. FILM NO. 2

Aluminum Penetrometer Step	Densitometer Readings				Average
1	2.32	2.33	2.24	2.24	2.28
2	1.67	1.67	1.63	1.63	1.65
3	1.25	1.27	1.25	1.27	1.26
4	0.93	0.97	0.93	0.97	0.95
5	0.71	0.75	0.73	0.76	0.74
6	0.59	0.61	0.59	0.62	0.60
7	0.49	0.51	0.49	0.52	0.50
8	0.45	0.48	0.47	0.50	0.48

Tooth	Enamel		Dentine	
	Densitometer Readings	Interpolated mm. Al	Densitometer Readings	Interpolated mm. Al
1	0.69	1.32	1.22	0.81
	0.67	1.36	1.26	0.78
			1.27	0.77
			1.30	0.76
			1.28	0.77
			1.33	0.74
2	0.72	1.28	1.21	0.82
	0.70	1.31	1.15	0.86
	0.73	1.27	1.22	0.81
	0.70	1.31	1.26	0.78
			1.15	0.86
			1.17	0.85
			1.20	0.82
			1.28	0.77
			1.28	0.77

In the densitometer readings in the enamel of tooth No. 1, two areas have been measured, reading 0.67 and 0.69 respectively. When inter-

polated into the corresponding millimeters of aluminum (Figs. 4 and 5) these give values of 1.36 and 1.32, a difference due to a different amount of absorbing material in the two areas. In tooth No. 2, densitometer readings of 0.70, 0.70, 0.72, and 0.73 density units are obtained in the enamel, which give 1.31, 1.31, 1.28 and 1.27 mm. of aluminum equivalent. The difference between 1.27 and 1.28 is of doubtful significance, but the difference between 1.31 and 1.27 and 1.28 is probably real, although of the order of only 1 per cent of the total absorption.

In tooth No. 1, densitometer readings in the dentine range from 1.22 to 1.33 density units, or from 0.81 to 0.74 mm. of aluminum. In tooth No. 2, densitometer readings in the dentine range from 1.15 to 1.28 density units, or from 0.86 to 0.77 mm. of aluminum. The higher values in some parts of the dentine than in others may be taken as evidence of more absorbing material present per unit volume, since the slabs are of the same thickness throughout. In certain cases[1] anatomical changes, such as the attrition in tooth No. 2, produce changes which may be given quantitative study by these measurements. For example, inside the whitish triangle under the worn tooth incisal surface, a density equivalent to 0.86 mm. of aluminum is observed, while just outside this triangle the dentine gives a density equivalent to 0.81 and 0.78 mm. of aluminum. The radiopaque triangle is thus found to have an increased absorption equivalent to 0.05 to 0.08 mm. of aluminum, or an increase of 6 to 10 per cent. The interpretation and significance of this increase is outside the scope of this paper. Suffice it to state that a quantitative measurement of tissue changes can be accomplished.

Differences in densitometer readings, or in millimeters of aluminum, of greater than 0.02 are to be considered as real. Therefore, the average value given for a series of readings in the same place on the same film may be indicated with a probable error of about 1 per cent, and differences between different areas expressed with a probable error of about 2 per cent.

DISCUSSION

A simple procedure for obtaining optimum exposure conditions primarily entails establishing the optimum peak kilovoltage and the optimum exposure time. These factors may be satisfactorily established in four steps, i.e., (1) the change of exposure time at given peak kilovoltage, (2) the change of peak kilovoltage for various exposure times, (3) the plotting of density-thickness curves and selecting the optimum peak kilovoltage, and (4) from the graphed curves, choosing optimum exposure time at optimum peak kilovoltage.

(1) A series of exposures are made with more or less equal time increments; for example, 1, 2, 3, 4, 5 and 6 seconds at 30 peak kv., with any set tube-film distance and current factors, say 68 cm. and 30 ma. This results in density values ranging from marked underexposure to marked overexposure. The densitometer readings under the penetrometer steps are plotted as ordinates (Fig. 6) against the proper thickness of aluminum as abscissae. A group of curves is obtained in which greater densities under each step are recorded with increasing exposure, so that the density-thickness curves are more or less parallel and fairly regularly spaced above each other in order of the length of exposure, the longest exposure being highest, the shortest, lowest.

(2) The same procedure is repeated for 25, 40, and 50 kv. peak.

(3) From each of the charts at given peak kilovoltage, one density-thickness curve is chosen in which the densitometer reading in step 1 is approximately 1.5. These curves (Fig. 7) are compared, and the curve having the greatest slope is chosen as representing the optimum kilovoltage for further study, since a given difference in densitometer readings gives the smallest difference in millimeters of aluminum upon interpolation from this curve.

(4) Having established the optimum peak kilovoltage (in this case approximately 30 kv.), a density-thickness curve having the optimum exposure time is selected from the group of curves found in the first procedure. That density-thickness curve is chosen whose densitometer reading under the thickest step is above 0.5 density units. This density is arbitrarily so chosen that the densitometer reading under 1 mm.

thickness of enamel will be 0.7 or greater. This condition is imposed in order to keep the photographic images of the enamel and dentine in that portion of the density range of the film which gives the film correct proportional densities for the two tissues. Experimental verification of this condition will be presented later.

A careful study of the variation in interpolated values of enamel and dentine has shown that the penetrometer must be chosen to fit the tissue being studied. For example, when a series of roentgenograms are made at varying peak voltages, the interpolated values in millimeters of aluminum for dentine are found to be independent of the voltage. This independence of change in experimental factors is important, since small changes in the voltage or other experimental factors are unavoidable. On the other hand, voltage changes give values in millimeters of aluminum for enamel which are found to be dependent on the voltage. Therefore, small and unavoidable changes in voltage would destroy the precision of the method. By proper choice of penetrometers this difficulty may be obviated. The condition which must be fulfilled in order that a penetrometer be satisfactory is as follows: the mass absorption coefficient of the penetrometer must be the same as the mass absorption coefficient of the tissue. Aluminum fulfills this condition for use as a standard for comparison against dentine. An alloy of 94 per cent aluminum and 6 per cent zinc has been found to fulfill the condition for enamel (data to be presented later). Inasmuch as we have been interested particularly in the dentine, the values listed in the tables are given in terms of millimeters of aluminum for both dentine and enamel.

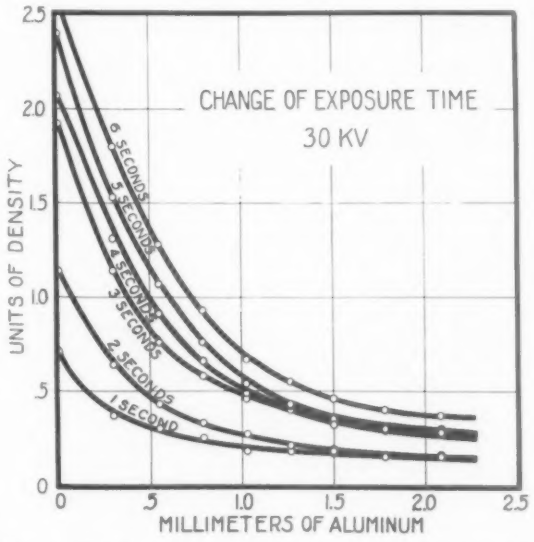

Fig. 6. Density-thickness curves obtained at 30 kv. at 1, 2, 3, 4, 5 and 6 second exposures.

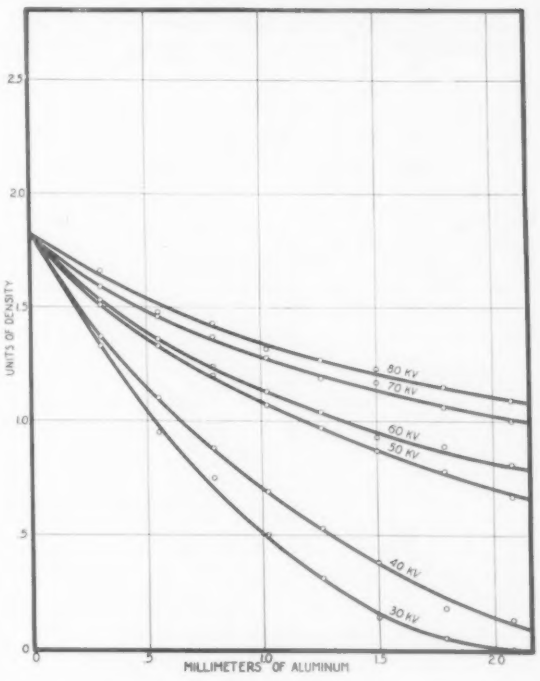

Fig. 7. Density-thickness curves at 30, 40, 50, 60, 70 and 80 kv. Note increasing slope of density-thickness curve with decrease in kv.

REPRODUCIBILITY

In order to study the possible factors* influencing the precision of the method, a careful analysis of each step of the procedure was made and a series of experiments were carried out on each substep, identifiable as such and capable of being tested experimentally. The findings of these somewhat digressive and yet related groups of

* These factors have been found to be unimportant provided the condition mentioned above is fulfilled, except variations in thickness of the film.

experiments are to be presented elsewhere in some detail; suffice it here to enumerate the factors tested.

The factors in the experimental procedure which were tested may be divided for convenience into three heads, as follows:

I. Mechanical factors of tube and machine
  a. focus
    x. enlargements by penumbra
  b. distance

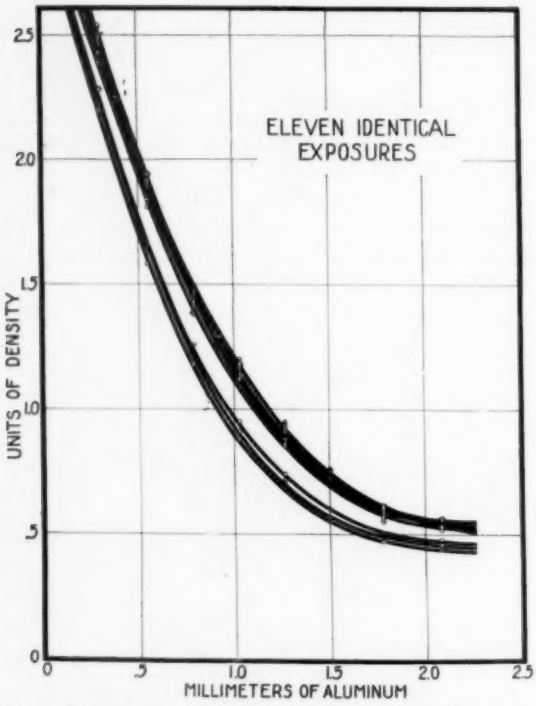

FIG. 8. Density-thickness curves for eleven identical exposures. The lower series of three curves were taken (see Table II) on a different day than the upper series of eight curves. The difference in their ordinates for a given aluminum thickness represents unavoidable differences in power factor, etc.

  c. exposure
    x. variation in time at kilovoltages of 20, 25, 30, and 50
  d. filters
    x. tube stand filter
    y. cassette cardboard filter
  e. voltage
  f. milliamperage
  g. wave form
II. Radiation factors
  a. monochromatic radiation
  b. white radiation
  c. Grenz radiation
  d. secondary radiation
  e. r output vs. photographic density
III. Film factors
  a. type of film, i.e., x-ray duplitized film, radiatized dental film, lantern slides, special fine-grain film, panchromatic photographic film
  b. development time
  c. fog

Factors influencing the reproducibility and not conveniently classed in the preceding outline may be considered under four heads, as follows:

I. Tube factors
  a. hot and cold tube
  b. output at identical exposure times at different voltages
II. Radiation factors
  a. series of identical roentgenograms at constant experimental conditions at various kilovoltages
  b. relation between magnitude of density read by densitometer and magnitude of interpolated values in terms of millimeters of aluminum
  c. filtration effect of emulsion
III. Penetrometer factors
  a. step tablet, composition, dimensions and other properties
  b. thickness of tooth slab
IV. Subjective factors
  a. accommodation
  b. fatigue

In addition to these factors, brief investigations were carried out to ensure correctness *photographically* of our procedure. These investigations involved a study of (*a*) density vs. exposure, (*b*) density vs. log exposure, (*c*) gamma vs. thickness of aluminum, (*d*) development procedure, (*e*) comparisons of emulsion thickness and type, and (*f*) photographic gradients and sharpness of images. Careful study of the data obtained shows that the factors named above do not influence the reproducibility of the results, with the exception of the possible variations in the emulsions of different films.

To illustrate the reproducibility of the method, the data on eleven films of two

different tooth slabs are noted in Table II (Fig. 8). The date, film number, kilovoltage, milliamperage, exposure time in seconds, distance from tube to film in centimeters, are given, together with the average densitometer readings in density units and the interpolated values in terms of millimeters of aluminum for both dentine and enamel. In tooth No. 1 the interpolated values vary from 0.76 to 0.82 mm. of aluminum in the dentine, and from 1.25 to 1.33 mm. of aluminum in the enamel. In tooth No. 2 the interpolated values vary from 0.78 to 0.85 mm. of aluminum in dentine, and from 1.26 to 1.36 mm. of aluminum in the enamel. However, the standard deviations about the several averages are seen to give the following ranges of variation: Tooth No. 1: dentine -0.79 ± 0.018, enamel -1.29 ± 0.022; tooth No. 2: dentine -0.81 ± 0.020, enamel -1.32 ± 0.028. The average of the standard deviations is thus 0.022,

TABLE II

Conditions						Dentine		Enamel	
Date	Film	Kv.	Ma.	Sec.	Cm. Dist.	Average Densit. Read.	Interpolated mm. Al	Average Densit. Read.	Interpolated mm. Al
Tooth No. 1									
1932 12–13	1	32	30	10	76	1.49	0.80	0.88	1.33
	2					1.48	0.80	0.90	1.28
	3					1.47	0.82	0.89	1.32
	4					1.48	0.79	0.90	1.28
	5					1.42	0.80	0.88	1.27
	6					1.49	0.78	0.90	1.31
	7					1.46	0.78	0.89	1.27
	8					1.39	0.81	0.88	1.25
1932 12–10	2	32	30	10	76	1.29	0.76	0.72	1.27
	3					1.22	0.76	0.69	1.28
	4					1.24	0.79	0.70	1.28
Average ± standard deviation							0.79 ± 0.018		1.29 ± 0.022
Tooth No. 2									
1932 12–10	2	32	30	10	76	1.20	0.80	0.74	1.26
	3					1.19	0.78	0.65	1.32
	4					1.21	0.81	0.67	1.32
1932 12–13	1	32	30	10	76	1.46	0.80	0.87	1.34
	2					1.48	0.80	0.88	1.30
	3					1.46	0.83	0.92	1.29
	4					1.51	0.78	0.85	1.33
	5					1.44	0.85	0.81	1.36
	6					1.44	0.82	0.84	1.36
	7					1.45	0.79	0.86	1.30
	8					1.38	0.82	0.83	1.32
Average ± standard deviation						0.81 ± 0.020			1.32 ± 0.028

and the average error of this range is less than 5 per cent of the total value. Although in certain series of twenty identical roentgenograms much higher precision has been found, the values listed in the table are typical values, without choosing or culling, and represent all the interpolated values.*

CONCLUSIONS

1. A densitometric method is described for the study of variations in the absorption of roentgen radiation by 1 mm. thick, plano-parallel tooth slabs.

2. By meticulous attention to detail, and by following the directions cited, the roentgen-ray absorption of a given portion of a tooth slab may be expressed in terms of equivalent millimeters of aluminum, with a total error of less than 5 per cent.

3. In a given film, the roentgen-ray absorption of different portions of the same tooth slab may be compared with a probable error of 2 per cent.

* By stipulating that the difference in densitometer readings in the darkest (thinnest) step be not greater than 0.05 density unit, a variation in interpolated values of not over 3 per cent is achieved.

We take pleasure in acknowledging the valuable assistance rendered by R. B. Wilsey, L. A. Jones, and V. C. Hall of Eastman Kodak Company; by F. E. Challis, J. W. Forrest, E. S. Bissell, H. F. Kurtz, G. Fassin, C. E. Bahn, and J. A. Roesser of Bausch and Lomb; by Prof. T. R. Wilkins and H. E. Wilder of the University of Rochester; by W. F. Bale, L. A. Mucci, and C. B. Alden of the Medical School of the University of Rochester; and by J. F. Timmons of James Picker, Inc.

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Vol. XXXI, No. 5

RADON INGESTION AND ITS POSSIBLE HEALTH DANGERS

By HOWARD H. BARKER
NEW YORK CITY

IT IS proposed to apply a little arithmetic to some questions in which radioactive constants are concerned.

What will be the number of alpha particles available for bombarding the system of the operator during a year?

Let us consider the case of an average female operator, engaged in the application of self-luminous material to clock dials, etc., who, we will assume, works 8 hours a day, 5 days a week and 50 weeks a year; has a total lung capacity of 1,800 c.c., and that during the working period her lungs are filled with the air of the workroom, and that the radon content of her circulatory system is equivalent to the radon in the lungs. It has been recently determined by a group of competent investigators that the average radon content of workshops, where applicators are engaged in the application of luminous material to dials, etc., is approximately 5×10^{-11} curies per liter; such activity is about 500 times the radon content of normal outdoor air. With these facts as a basis, and assumptions to be later specified, there are certain questions which would seem to be pertinent in determining whether the exposure is of such a nature that it might prove deleterious. From known constants of the radioactive family, it is possible to answer mathematically some of these questions in a manner which should be significant and conclusive.

It is assumed that the total amount of radon which an operator can have in her system during her working period will be equivalent to that contained in 3.6 liters of air, namely, 1.8×10^{-10} curies.

One curie of radon and its short-lived products, emits $4\times3.7\times10^{10}$ alpha particles per second, then 1.8×10^{-10} curies will emit:

$1.8\times10^{-10}\times3.7\times10^{10}\times4=26.64$ alpha particles per second, multiplying by the annual working period expressed in seconds, 7.2×10^{6}, we get 1.91×10^{8} for the total number of alpha particles emitted annually in the system.

Since 1 gram of Ra emits 14.88×10^{10} alpha rays per second, it will emit annually

$$14.88\times10^{10}\times3.15\times10^{7}=4.69\times10^{18}$$

alpha particles; or from 1 microgram of radium element deposited in the system 4.69×10^{12} alpha particles would be emitted annually, a quantity 24,000 (2.4×10^{4}) times that which could be produced by the radon in the system on an annual basis. That is, the alpha rays arising from the radon in the air filling the lungs and contained in the circulatory system of the operator during the working period per annum would be equivalent to the alpha rays produced annually from a deposit of 4.1×10^{-5} micrograms (0.000041 micrograms) in the system.

Assuming that all the polonium formed from the radon remains in the system, how many alpha particles will be emitted annually?

It has been assumed that 1.8×10^{-10} curies is the maximum quantity of radon in the system of the operators at any one time. If it is further assumed that this maximum quantity is always present during the working period, we can then compute the number of alpha particles this quantity of radon will produce per annum: $1.8\times10^{-10}\times3.7\times10^{10}\times7.2\times10^{6}=4.79\times10^{7}$ alpha particles. Each transformation of a radon atom produces an atom of Ra D; therefore, the total number of atoms of Ra D formed and deposited in the system will be the same as the number of alpha particles produced annually, or 4.79×10^{7}. The fraction of Ra D atoms decaying per second is about 1.37×10^{-9}; therefore, the

number of atoms of polonium which will be formed per second will be:

$$4.79\times10^{7}\times1.37\times10^{-9}=6.56\times10^{-2}$$

If it is assumed that this process of transformation of Ra D goes on for a year, then the total number of atoms of polonium will be:

$$6.56\times10^{-2}\times3.15\times10^{7}=2.07\times10^{6}$$

However, the fraction of polonium atoms decaying per second is 5.9×10^{-8}, and therefore the number of alpha particles available for bombarding the tissues annually will be:

$$2.07\times10^{6}\times5.9\times10^{-8}\times3.15\times10^{7}=3.84\times10^{6}$$

Considering that 1 microgram of radium element deposited in the system will produce 4.69×10^{12} alpha particles annually, it is readily seen that the alpha radiation that could possibly have its origin from the polonium formed from the radon inhaled by an operator in an application plant would be practically negligible. As a matter of fact, it would be equivalent to the number of alpha rays produced annually by a deposit in the system of:

$$\frac{3.84\times10^{6}}{4.96\times10^{12}}=8\times10^{-7}\text{ micrograms}$$

(0.000,000,8μgm.)

It is also noted that the radon in the system of the operator during the working period on an annual basis will produce 1.91×10^{8} alpha rays, while for the first year of the life of the polonium produced from an amount of radon necessary to emit 1.91×10^{8} alphas, there will be emitted 3.84×10^{6} alpha rays.

$$\frac{3.84\times10^{6}}{1.91\times10^{8}}=2\times10^{-2}=0.02\text{ or }2\text{ per cent.}$$

What are the possibilities of polonium, which has been formed from the decay of radon, remaining in the human system?

From the work of Schlundt and Failla,[1] it would not be logical to assume that all of the Ra D produced from the radon would remain in the system. Schlundt and Failla found that about 0.004 per cent of the radium lodged in the system is eliminated daily. It is quite reasonable to assume that Ra D will be eliminated at about the same rate as radium. Per microgram of Ra then, the elimination of Ra D will be 4×10^{-11} grams per day. It has previously been computed that the subject in question has a daily exposure to 1.8×10^{-10} curies. Since 1 curie of radon weighs 6.6×10^{-6} grams, 1.8×10^{-10} curies will weigh:

$$1.8\times10^{-10}\times6.6\times10^{-6}=1.19\times10^{-15}\text{ gm.}$$

If we assume that the quantity of radon in the system daily is all transformed into Ra D there would be formed in the system 1.19×10^{-15} grams of Ra D. However, it has been pointed out that the elimination of Ra D would probably be 4×10^{-11} micrograms per microgram of Ra. On this basis the quantity eliminated daily would be:

$$1.8\times10^{-10}\times4\times10^{-5}\text{ or }7.20\times10^{-15}\text{ gm.}$$

a quantity approximately six times the quantity that would be formed daily. Apparently then, Ra D could not accumulate in the system of an operator working under the above specified conditions.

It is now proposed to give brief consideration to the possible harm both current and latent, that might result from the daily ingestion of radon, either through inhalation or when contained in drinking water. It will be assumed that a daily dosage of 8,000 Mache units is administered for a period of eight weeks, and that regardless of the type of administration the dose remains in the system for a period of 15 minutes. With this assumption it is possible to compute the alpha-ray exposures, and by further assuming that all of the Ra D formed remains in the system it is possible to compute the alpha-ray exposure which may arise from polonium formed. Eight thousand Mache units is equivalent to approximately 3 microcuries of radon which if introduced daily over a period of 8 weeks would amount to 168 microcuries. If it is

[1] Schlundt, H., and Failla, G. The detection and estimation of radium in living persons. III. The normal elimination of radium. AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *26*, 265–271.

further assumed that the entire dosage of 168 microcuries was administered as one dose, and that it all remained in the system for 15 minutes, the number of alpha rays that will bombard the system may be computed:

$$1.68\times10^{-4}\times3.7\times10^{10}\times4\times60\times15 = 2.24\times10^{10}$$

The alpha rays arising from 1 microgram of radium deposited in the system during 8 weeks would be:

$$10^{-6}\times3.7\times10^{10}\times4\times60\times60\times24\times56 = 7.2\times10^{11}$$

That is, the alpha rays emitted by 1 microgram deposited in the system for a period of 8 weeks would probably be about thirty times the alpha rays available for bombarding the system with a daily ingestion of 8,000 Mache units.

Since each transformation of a radon atom produces an atom of Ra D, the total number of atoms of Ra D formed will be 2.24×10^{10}. The fraction of Ra D which decays per second is approximately 1.37×10^{-9}, therefore:

$$2.24\times10^{10}\times1.37\times10^{-9}=30.7$$

atoms of polonium will be formed per second.

If it is assumed that this process of transformation continues for a year, the number of atoms of polonium will be:

$$30.7\times60\times60\times24\times365=9.7\times10^{8}$$

However, 5.9×10^{-8} decay per second, each emitting an alpha particle; thus the number of alphas bombarding the tissues during the first year will be approximately:

$$9.6\times10^{8}\times5.9\times10^{-8}\times3.15\times10^{7}=1.76\times10^{9}$$

During the second year this number may increase somewhat, but after that it will progressively decrease. It has been computed that the number of alphas arising from 168 microcuries of radon in the system for a period of 15 minutes will be 7.2×10^{11}, while the number of alphas arising from the deposit of polonium from the same quantity of radon will be 1.76×10^{9} per annum. That is, the alpha rays expelled from the radon during its short stay in the system is approximately 400 times that which would be produced from the polonium on an annual basis. However, it has previously been shown that the possibility of any polonium remaining in the system is very remote.

SUMMARY

It has been pointed out by mathematical calculations which have been coordinated with experimental data:

1. That the exposure of an operator in a dial painting laboratory to the emanation in the atmosphere of the laboratory does not in all probability constitute a hazard. Based on typical working conditions the alpha-ray exposure is no more than it would be if there were permanently deposited in the system 0.00004 micrograms of radium element, a quantity insignificant in comparison with the safe tolerance of the individual.

2. That the alpha radiation resulting from the polonium formed from the active deposit is at the best very nominal, and probably about 2 per cent of the alpha radiation produced by the radon.

3. That the chances for any accumulation of the active deposit of slow change in the system is practically nil.

4. That the possibility of any harmful effects resulting from the ingestion of radon as administered therapeutically either by inhalation or injection is very remote.

TRANSVERSE FRACTURE OF THE SACRUM

REPORT OF A CASE

By WILLIAM E. ALLEN, JR., M.D.

Department of Radiology, City Hospital No. 2

ST. LOUIS, MISSOURI

TRANSVERSE fracture of the sacrum according to Muresanu[1] is a relatively rare condition. Quoting Guillot, he claims that only 40 cases had been collected from the literature at the time of his case report, May, 1931.

The fracture service of a municipal hospital in a large metropolis is necessarily one of the heaviest services. This is particularly true of this institution. During the routine examination of hundreds of cases, we often discover many interesting and unusual ones. The following case belongs to this class.

FIG. 1.

Patient No. 5147, colored male, aged twenty-four, a laborer by occupation, was given emergency treatment at City Hospital No. 2 on August 23, 1932, for lacerations of the left supraorbital region and contusions on the back. He gave a history of having been in a fight during which he was struck several times across the lower lumbar region with a baseball bat.

Physical examination at this time failed to reveal any findings of sufficient significance to warrant the patient's remaining in the hospital. However, due to the manner in which he received his injuries, the receiving physician felt that the patient should be hospitalized for further study. This was recommended, but refused. The patient was then permitted to go home with the advice to return to the hospital should his condition become worse.

The next day the patient returned to the hospital complaining of difficulty in walking and pain in the lower lumbar region. He was admitted to the hospital and sent to the surgical ward. The physical examination at this time revealed a well-developed male, lying uncomfortably in right lateral position. He was complaining bitterly of lower lumbar pain. There were several superficial lacerations in the left supraorbital region. Study of the lower back revealed two large contusions, one on each side extending across both sacroiliac regions. These sites were moderately swollen and tender. Pressure produced exquisite pain. The classical findings of fracture were not elicited. There was no further evidence of injury, nerve involvement, or of injury to the pelvic viscera. A provisional diagnosis of probable fractured lumbar spine was made and the patient sent to the Department of Radiology for examination. The radiologist's report was as follows: "There is a fracture of the sacrum extending transversely across the body; no separation of the fragments. There is a spina bifida occulta of the first sacral segment." (Fig. 1).

A plaster cast was immediately applied and kept on for eight weeks. The cast was then removed and the patient roentgenographed. Very little new bone formation was discovered and was so reported. However, the patient's physical condition was such that the surgeons felt justified in permitting him to remain out of the cast and to sit up in a wheel chair. A few days later he was allowed to walk about the ward. At this time he experienced no difficulty in walking, was free of complaint and consequently was discharged much improved. A follow-up study some time later found the patient well, back on his regular job and apparently suffering no disability.

[1] Muresanu, E. Fractura transversală a sacrului. *Cluj. med.*, 1931, *12*, 280–283. Abs. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *27*, 646.

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19th Annual Meeting: Cleveland, June 11–12, 1934.

EDITORIALS

INTRACARDIAC CALCIFICATION

IN JULY, 1931, Dr. Henry A. Christian called attention to a distinct clinical entity, namely, aortic stenosis with calcification of the cusps. After a clear cut clinical and pathological description of the disease process, he threw a challenge to the roentgenologist by this statement: "From observing the calcareous deposits in these heart valves it is evident that roentgenography with proper technique should often demonstrate the calcification in the living patient."[1] It must be a source of considerable pride that this challenge was so shortly met in his own clinic by Sosman and Wosika[2] who reported a group of cases in which they were able to visualize both roentgenoscopically and roentgenographically the calcified heart valves during life. Not only were they able to demonstrate calcification in aortic stenosis but also they reported a group of cases with calcification in the mitral valve leaflets. This report of Sosman and Wosika's was followed shortly by a report of Bishop and Roesler[3] on the roentgenologic diagnosis of intracardiac calcifications. It is true that pericardial calcifications had been reported before but the reports on calcifications of the valves themselves had been so meager as to have passed unnoticed. Saul[4] in 1932 reported three cases of intracardiac calcifications with observations and conclusions quite similar to those of Sosman and Wosika's, the observations having been made at the same time without being aware of the American literature on this subject. Shortly after Saul's publication, Parade and Kuhlmann[5] published four cases of intracardiac calcification, three in the mitral valve and one in the aortic valve. But Sosman and Wosika's clear cut description of the technique of the examination and the report of their large group of cases placed the roentgenoscopic and roentgenographic diagnosis of intracardiac calcification on a sure footing.

Not content with the demonstration of the calcification of the valves, Sosman and Wosika turned their attention to a more minute and intensive study of the cardiac shadow itself and they have recently reported the roentgen demonstration of calcified coronary arteries in living subjects.[6] With the increasing death rate from cardiovascular disorders and the not only apparent but definite increase in coronary artery disease, this observation of Wosika and Sosman's is of considerable clinical importance. As coronary disease is insidious in its onset and the first and often the only clinical manifestation of the disease may be the patient's history of anginal attacks, the demonstration of calcification in the coronary artery would be of considerable importance in the prognosis and the therapeutic measures to be instituted. Arteriosclerosis is by far the most common lesion of the coronary arteries, for in a recent report[7] from the Department of Medicine, College of Physicians and Surgeons of Columbia University, 97.2 per cent of the cases showed calcification. While it is true

[1] Steel, David. Aortic stenosis with calcification of the cusps. (Editorial.) AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *26*, 468.

[2] Sosman, M. C., and Wosika, P. H. Calcification in aortic and mitral valves. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *30*, 328–348.

[3] Bishop, P. A., and Roesler, H. The roentgenologic diagnosis of intracardiac calcifications. AM. J. ROENTGENOL. & RAD. THERAPY, Jan., 1934, *31*, 1–15.

[4] Saul. Quoted by Sosman and Wosika.

[5] Parade and Kuhlmann. Quoted by Sosman and Wosika.

[6] Wosika, P. H., and Sosman, M. C. The roentgen demonstration of calcified coronary arteries in living subjects. *J. Am. M. Ass.*, Feb. 24, 1934, *102*, 591–593.

[7] Levy, R. L., Bruenn, H. G., and Kurtz, Dorothy. Facts on disease of the coronary arteries, based on a survey of the clinical and pathologic records of 762 cases. *Am. J. M. Sc.*, March, 1934, *187*, 376–390.

that lesser degrees of sclerosis were observed predominantly in the younger age groups, the more marked lesions developing with advancing years, it nevertheless is of importance to diagnose these cases early as coronary artery disease has increased at all age levels as shown by this report; the increase is particularly noteworthy between the ages of twenty-five and forty-four, these representing the most active years of life. If any method or combination of methods will add to the detection of coronary disease earlier it is to be utilized. The technique of the demonstration of both the calcified valves and of the calcification in the coronary arteries is so simple that it may be followed easily and now that Sosman and Wosika have placed the diagnosis on such a solid basis it is to be hoped that the roentgenologist will not only confine himself to the study of cardiovascular diseases by measurements of the cardiac shadow in its various positions that has heretofore been followed but that he will devote himself also to a more intensive study of the cardiac shadow, in the hope of being able to demonstrate these intracardiac calcifications at a time when their diagnosis will add considerably to the patient's welfare. Undoubtedly intracardiac calcifications are much more frequent than is generally supposed and the roentgenologist stands in a unique position to demonstrate these in the living by a more careful roentgenoscopic examination of the heart in routine chest examinations.

STANLEY MELVILLE, M.D. (Brux.), M.R.C.P. (Lond.)
1868-1934

IT IS with a profound sense of sorrow that we learn of the death of Dr. Stanley Melville of London, which occurred on April 6. Those who were privileged to attend the First International Congress of Radiology in London in 1925 will long remember with great pleasure this charming personality who contributed so much to the success of that meeting. He gave not only of his time and his efforts toward the organization of the Congress itself, but he was unsparing in his kindness and services to the foreign guests present.

Stanley Melville needs no introduction to the radiological and medical world because his name has long been outstanding as an investigator of medical and radiological problems, and his contributions have been received with the greatest enthusiasm because behind them stood the knowledge and reputation of a careful worker. He is particularly remembered abroad for his roentgenologic studies on diseases of the chest and for his splendid and timely work in collaboration with G. W. C. Kaye on the British X-Ray and Radium Protective Committee, the first of its kind in any country, whose recommendations on protection were adopted internationally at the Second International Congress of Radiology at Stockholm.

Many honors were bestowed upon Dr.

Melville during his life; he was at various times president of the Electrotherapeutic Section of the Royal Society ofMedicine, president of the Radiological Section of the British Medical Association, secretary of the British Institute of Radiology, and secretary-general of the First International Congress of Radiology held in London in 1925, and to him the British Institute of Radiology owes a tremendous debt for the high position which it holds in the realm of radiology today. Dr. Melville acted as examiner in radiology at both Cambridge and Liverpool Universities and was one of the founders of the Society of Radiographers and its first president.

As early as 1898 Dr. Melville began to interest himself in the new science of radiology and was shortly appointed radiologist to the West London Hospital, later to St. George's Hospital and still later to the Brompton Hospital for Diseases of the Chest. In these early days of work with the roentgen ray he, not knowing of the risks, received injuries to his hands from which he suffered acutely during the latter years of his life. The immediate cause of Dr. Melville's death was heart disease. His death at this particular time is a great loss not only to those more closely associated with him but because a few days before his death he had accepted nomination as medical editor of the *British Journal of Radiology*. Could he have lived to edit this splendid journal his influence which has been so wholesome in England could have been utilized for a broader scope. The American Roentgen Ray Society together with the readers of the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY express their profound sense of loss in the death of Stanley Melville, for in the words of Sir Humphry Rolleston "the radiological world has lost a great soul."*

* We are indebted to an obituary notice of Dr. Melville published in the *Lancet*, April 14, 1934, *1*, 815, for much of the material here presented.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa.
Annual Meeting: Hotel William Penn, Pittsburgh, Pa., Sept. 25–28, 1934.

American College of Radiology
Secretary, Dr. Albert Soiland, 1407 S. Hope St., Los Angeles, Calif.
Annual meeting: Cleveland, 1934.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio.
Annual meeting: Cleveland, Ohio, June 11–15, 1934.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y.
Annual meeting: Memphis, Tenn., Dec. 3–7, 1934.

Radiological Section, Baltimore Medical Society
Secretary, Dr. W. B. Firor, 1100 N. Charles St., Baltimore.
Meets third Tuesday each month, September to May.

Radiological Section, Los Angeles County Medical Society
Secretary, E. N. Liljedahl, Los Angeles, Calif.
Meets on the third Wednesday of each month at the California Hospital.

Radiological Section, Southern Medical Association
Secretary, Dr. F. B. Bogart, Medical Arts Bldg., Chattanooga, Tenn.
Annual meeting: San Antonio, Texas, November, 1934.

Brooklyn Roentgen Ray Society
Secretary, Dr. A. L. Voltz, 115 Myrtle Ave., Richmond Hill, N.Y.
Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N.Y.
Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt.
Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, General Hospital, Cincinnati, Ohio.
Meets third Monday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. Otto Glasser, Cleveland Clinic.
Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital.
Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida Radiological Society
Secretary, Dr. W. McL. Shaw, 418 St. James Bldg., Jacksonville, Fla.
Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. H. W. Grote, 219 N. Main St., Bloomington, Ill.
Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. J. N. Collins, Indianapolis, Ind.
Annual meeting each February 22 in Indianapolis.

Michigan Association of Roentgenologists
Secretary, Dr. S. W. Donaldson, St. Joseph's Mercy Hospital, Ann Arbor, Mich. Three meetings a year, Fall, Winter, and Spring. Next meeting, Grand Rapids, Mich., May, 1934.

Milwaukee Roentgen Ray Society
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis.
Meets monthly. Place of meeting designed by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

New England Roentgen Ray Society
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass.
Meets monthly on third Friday, Boston Medical Library.

New York Roentgen Society
Secretary, Dr. C. W. Schwartz, 33 E. 68th St., New York.
Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N.C.
Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. F. C. Rulison, Medical Arts Bldg., Syracuse, N.Y.
Three meetings a year—January, May, and November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif.
Meets annually, during meeting of California Medical Association

Pennsylvania Radiological Society
Secretary, Dr. W. E. Reiley, Clearfield, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. Thomas Loughery, Germantown Hospital.
Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N.Y.
Secretary, Dr. W. W. Fray, Strong Memorial Hospital.
Meets monthly on second Thursday from October to May, inclusive, at 7:45 at the Rochester Medical Association Building.

St. Louis Roentgen Club
Secretary, Dr. W. K. Mueller, University Club Bldg.
Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston.
Meets at time and place of South Carolina State Medical Association.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg., Chattanooga, Tenn.
Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary-Treasurer, Dr. J. H. Smith, Lubbock, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association. Next Meeting. San Antonio, May 7, 1934.

University of Michigan Department of Roentgenology Staff Meeting.
Secretary, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 P. M. at University Hospital.

University of Wisconsin Roentgen Club
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 P.M.

Virginia Roentgen Ray Club
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Luis Fariñas, Animas 110, Havana, Cuba.
Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1., or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Indian Radiological Association
Secretary, Sd. Subodh Mitra, 148 Russa Rd., Calcutta.
Meets annually in January, and at such places and times as the Council may appoint.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Allies, 134, Louvain, (Belgian).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summer time.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Française d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11/52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April in different German cities, at least once in five years in Berlin. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Maracine 30, Bucharest, Rumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR, in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw.
Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summer time.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summer time.

Society of Medical Radiology of Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. H. Scheuermann, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Society of Roentgenology
Meets first Tuesday each month, October to July.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike, Kyoto, Japan.
Meets bi-monthly on third Sunday.

PROGRAM OF THE NINETEENTH ANNUAL MEETING
AMERICAN RADIUM SOCIETY

MONDAY AND TUESDAY, JUNE 11 AND 12, 1934
CLEVELAND, OHIO

Place of Meeting—HOTEL CLEVELAND
Empire Room

9:00 A.M. EXECUTIVE SESSION
10:00 A.M. SCIENTIFIC SESSION

Address of President—ROLLIN H. STEVENS, M.D., Detroit

SYMPOSIUM ON RADIUM DOSAGE AND TECHNIQUE

I. PHYSICAL AND BIOLOGIC FACTORS

Chairman, GEO. E. PFAHLER, M.D., Philadelphia

10:20—*Physical Determination of Radium Dosages*, OTTO GLASSER, Ph.D., Cleveland.

10:30—*Physical Factors in Teleradium Dosage*. WILHELM STENSTROM, Ph.D., Minneapolis.

10:40—*Physical Factors in Intracavity Radium Dosage*. JAS. L. WEATHERWAX, Ph.D., Philadelphia.

10:50—*Physical Factors in Interstitial Radium Dosage*. EDITH H. QUIMBY, Ph.D., New York.

11:00—*Drosophila Eggs for Radium Dosimetry*. GEO. PACKARD, Ph.D., New York (*by invitation*).

11:10—*Clinical Considerations Influencing Radium Doage*. MAURICE LENZ, M.D., J. R. FREID, M.D., New York.

11:25—*Microscopic Structure of Oral Cancer and Its Relation to Radiosensitivity*. ARTHUR P. STOUT, M.D., New York (*by invitation*).

11:40—*Microscopic Structure of Carcinoma of the Uterus and Its Relation to Radiosensitivity*. CHAS. C. NORRIS, M.D., Philadelphia.

Discussion opened by: FRANCIS CARTER WOOD, M.D., New York, J. E. GENDREAU, M.D., Montreal, GEO. E. PFAHLER, M.D., Philadelphia.

MONDAY, JUNE 11, 1934

AFTERNOON SESSION

2:00 P.M. EXECUTIVE SESSION
2:30 P.M. SCIENTIFIC SESSION

II. BENIGN LESIONS

Chairman, ROLLIN H. STEVENS, M.D., Detroit

2:30—*Benign Lesions of the Skin*. LAWRENCE R. TAUSSIG, M.D., HOWARD MORROW, M.D., San Francisco.

Discussion—WM. S. NEWCOMET, M.D., Philadelphia.

2:45—*Benign Lesions of the Uterus*. JAS. A. CORSCADEN, M.D., New York.

3:00—*Benign Uterine Hemorrhage*. HENRY SCHMITZ, M.D., Chicago.

Discussion—CHAS. C. NORRIS, M.D., Philadelphia, CARL R. CRUTCHFIELD, M.D., Nashville.

3:15—*Benign Lesions of the Eye, Ear, Nose and Throat*. ALLEN G. ROBINSON, M.D., New York.

3:30—*Chronic Infection of the Parotid Gland*. G. M. DORRANCE, M.D., Philadelphia.

Discussion—ZOE A. JOHNSTON, M.D. Pittsburgh.

ANNUAL BANQUET

7:00 P.M. MONDAY, JUNE 11, 1934

Rose Room, Hotel Cleveland

Presiding Officer—PRESIDENT STEVENS

JANEWAY LECTURE

Recent Advances in Experimental Cancer Research

FRANCIS CARTER WOOD, M.D., New York

TUESDAY, JUNE 12, 1934

Morning Session

9:00 A.M. EXECUTIVE SESSION

9:30 A.M. SCIENTIFIC SESSION

III. Malignant Neoplasms

Chairman, George W. Grier, M.D., Pittsburgh

9:30—*Carcinoma of the Skin.* Harold N. Cole, M.D., J. R. Driver, M.D. (*by invitation*), Cleveland.

9:45—*Carincoma of the Cheek.* Hayes E. Martin, M.D., New York. Otto H. Pflueger, M.D., San Francisco (*by invitation*).

10:00—*Carcinoma of the Tongue.* Frank E. Simpson, M.D., Chicago.

10:15—*Carcinoma of Tonsil, Pharynx and Larynx.* Max Cutler, M.D., Chicago.

10:30—*Carcinoma of the Cervical Glands.* Douglas Quick, M.B. (Tor.), New York.

10:45—*Carcinoma of the Breast.* Grantley W. Taylor, M.D. Boston (*by invitation*).

11:00—*Carcinoma of the Fundus Uteri.* H. H. Bowing, M.D., Mayo Clinic, Rochester.

11:15—*Radium Treatment of Carcinoma of Cervix Uteri.* (Moving Picture Demonstration.) Lawrence A. Pomeroy, M.D., Cleveland.

11:25—*Carcinoma of Bladder.* Benj. S. Barringer, M.D., New York.

11:40—*Carcinoma of Rectum.* Wm. M. Shedden, M.D., Boston (*by invitation*).

Discussion opened by George W. Grier, M.D., Pittsburgh.

GENERAL DISCUSSION: Limited to 3 minutes each.

TUESDAY, JUNE 12, 1934

Afternoon Session

2:00 P.M. EXECUTIVE SESSION—ELECTION OF OFFICERS

2:30 P.M. SCIENTIFIC SESSION

IV. Miscellaneous Problems

Chairman, J. E. Gendreau, M.D., Montreal

2:30—*Complications and Injuries in Radium Therapy.* Ira I. Kaplan, M.D., New York.

2:40—*The Use and Abuse of Interstitial Radium Therapy.* Albert Soiland, M.D., Los Angeles.

2:50—*Hazards in the Use of Radium.* J. M. Sittenfield, M.D., New York.

3:00—*Design of a Flexible Radium Bomb with Adequate Protection, Delivering a Homogeneous Field of Irradiation at Various Distances.* Wm. S. Newcomet, M.D., B. A. Hughes (*by invitation*), Philadelphia.

3:10—*A Small Platinum Needle Designed for the Use of Various Strengths of Radium Element Interstitially.* Norman Treves, M.D., New York.

3:20—*Correction of Dietary Errors in Connection with Radium Treatment.* D. T. Quigley, M.D., Omaha.

3:30—*Adenocarcinoma of the Oral Cavity.* Wm. L. Watson, M.D., New York (*by invitation*).

3:40—*Intraperitoneal Insertion of Radon and Gastro-Enterostomy in Carcinoma of the Pyloric End of the Stomach.* Isaac Levin, M.D., New York.

3:50—*Abdominal Implantation of Radon Seeds Combined with Removal of Iliac Glands in the Treatment of Cancer of the Cervix (28 cases).* Fred J. Taussig, M.D., St. Louis.

GENERAL DISCUSSION: Limited to 3 minutes each.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

The Science of Radiology. Edited by Otto Glasser, Ph.D. The contributors are as follows: Harry H. Bowing, M.D., Percy Brown, M.D., James T. Case, M.D., Ernest E. Charlton, Physicist, George L. Clark, Ph.D., Arthur H. Crompton, Ph.D., William D. Coolidge, Ph.D., William A. Evans, M.D., Gioacchino Failla, Physicist, Robert E. Fricke, M.D., Arthur W. Fuchs, Otto Glasser, Ph.D., J. Cramer Hudson, Ph.D., Hans A. Jarre, M.D., Ed. C. Jerman, Sc.D., Matthew Luckiesh, Sc.D., George M. MacKee, M.D., Willis F. Manges, M.D., Hermann J. Muller, Ph.D., Charles Packard, Ph.D., Ursus V. Portmann, M.D., Edith H. Quimby, M.A., William Seifriz, Ph.D., Edward H. Skinner, M.D., Lauriston S. Taylor, Physicist., and David L. Webster, Ph.D. Pp. 450, with 108 illustrations. Springfield, Ill.; Baltimore, Md.: Charles C Thomas, 1933.

This work is the product of the American Congress on Radiology which had its beginning three years ago and which met in Chicago in 1933 during the Century of Progress. To give any adequate review of a work of complete or multiple authorship would require an evaluation of each contribution, which space will not permit. From the viewpoint of qualification the list of authors could not have been more happily selected, which may also be said of the selection of the chapter headings. The authors are so well known as to render unnecessary any mention of the positions they occupy in the various hospitals and other institutions of this country. The work is very largely historical and biographical, with the exception of several chapters which deal with the mathematical and physical aspects of radiology, which are for the most part by physicists of national standing. It is fitting that the history of radiology should be written and preserved at the end of the first third of a century. Thirty-three years, or sixty-six years hence, the period now written may shrink in historic perspective. It is the opinion of the reviewer, however, that it will occupy a large space, since the present period is an evolution from crude and uncertain beginnings to stability and certainty. The work is exceedingly well documented in such a way that nearly all the important early contributions on the broad subject of Radiology are listed by title. This compilation should be an important unit in the library of every radiologist and physicist as well. While a work of this nature can hardly be said to embrace the entire science of radiology, which would require several volumes, it contains a vast amount of information in readable form on pioneer discoveries, pioneer workers, on physics, biology, evolution of apparatus, photographic development and screens, therapy, diagnosis, roentgen rays and radium, industrial radiology, protection, military radiology, the nature of cosmic rays, Gurwitsch rays. The work is in no sense a textbook. Its essential appeal is to the specializing radiologist and the physician. Some sections will prove unintelligible to one whose interests in the subject are purely casual, yet the cultured reader will find much that will repay a perusal of this interesting book. The book is also a splendid achievement of the publisher's art.

J. H. Dempster

Trattato di Roentgen- e di Curie-terapia. (A Textbook on Roentgen and Radium Therapy.) Edited by Felice Perussia, Ordinario di Radiologia medica alla R. Universita di Milano, and Enzo Pugno-Vanoni, Straordinario di Elettrotecnica generale alla R. Scuola d'Ingegneria di Padova. With the collaboration of Prof. O. Alberti, Prof. M. L. Asti, Prof. E. Bortoni, Dott. L. Gallavresi, Prof. F. Giongo, Dott. G. Giraudi, Dott. F. Mascherpa, Dott. G. Meda, Dott. M. Pellini, Dott. C. Picchio and Prof. A. Ratti. Volumes I and II. Cloth. Price, L.350. Pp. 1600, with 700 illustrations. Milano: Fratelli Treves Editori, 1934. (This text is one of the "Monografia e Trattati di Biologia e di Medicina" collezione diretta dal Prof. Carlo Foa.)

This work is designed to be a complete systematic textbook on radiotherapy, of which there are none in Italian, in which the important facts of the subject are to be easily available and from which unessential matter is to be eliminated. This ideal the authors have

achieved in a highly successful manner. Not only have they avoided the inclusion of subjects of purely historic or academic interest but also have not omitted much of actual importance. This has been done by the authors' collecting and editing a series of presentations, each one written by a specialist in a particular field so that in the end each radiologic subject is given due prominence and is handled with becoming completeness.

The first volume (of 701 pages) is of the basic physical and biological conceptions on which radiotherapy rests. Pugno-Vanoni takes up the fundamentals of the modern physical theory of radiations, then a review of apparatus, dosimetry and protection (pages 3–230). Giongo elucidates the emission and absorption of roentgen radiation (pages 233–328) illustrating various technical methods of giving a "dose" of roentgen rays, and Asti (pages 329–460) of radium. Picchio supplements these sections by some excellent physical tables (pages 461–517). Gallavresi considers in due detail the fundamental biological effects of radiation (pages 519–681), and Ratti concludes with a consideration of the reactions and injuries from radiotherapy (pages 681–691).

The second volume (of 875 pages) is a clinical one. Perussia opens it with a general discussion of the radiotherapy of tumors (pages 3–25) which is elaborated and developed by Ratti (pages 27–296). Bortoni next discusses benign uterine hemorrhage (pages 297–346). Alberti takes up inflammatory disease (pages 347–458), Giraudi the treatment of tuberculosis (pages 459–530) and Meda the lymphoblastomas and the diseases of the hematopoietic system (pages 531–590). Pellini considers the internal medical diseases (pages 591–663), then Mascherpa writes on the radiotherapy of diseases of the endocrine and nervous systems (pages 663–776), Giraudi those of the bones and joints (pages 777–807) and Perussia closes with an excellent discussion of radiotherapy in dermatology. At the end of each chapter there is a bibliography of the important works on the subject considered. Throughout the whole work practical treatment problems are presented by abstracts of histories and photographs (some in color) or roentgenograms, and then are solved by a technique of treatment, which is illustrated profusely by photographs and diagrams, so that we actually see the daily routine of a busy therapist. Each volume has an index which facilitates reference to items in the text and completes the table of contents at the beginning of the book. Almost anyone can get the gist of the Italian text, even though one's knowledge of the language be but rudimentary. The authors and publishers deserve great commendation for bringing out this textbook which will rank high among the few excellent ones ever written.

Neurology. By Roy R. Grinker, Associate Professor of Neurology, the University of Chicago. Cloth. Price, $8.50. Pp. 979, with 401 illustrations. Springfield, Illinois; Baltimore, Maryland: Charles C Thomas, 1934.

This volume is a valuable one which has both the advantages and disadvantages of being encylopedic in its scope, fundamental approach and style. On its jacket, one reads that it "presents neurology as a part of the biological sciences rather than as a recount only of symptoms and signs of disease." This excellent ambition seems to the reviewer to have been achieved and for this departure in the field of neurologic textbooks, Grinker indeed deserves high praise.

The chapter on "general embryological considerations" including a good résumé of Kapper's theory of neurobiotaxis in the tracing of phylogenetic development, a particularly well-presented chapter on general anatomical considerations and some space devoted to psychochemistry, better called neurochemistry, are full of these biological correlations. The listing of all of the joint movements of the body with the muscles concerned is a good feature not usually seen. The chapter on the vegetative nervous system also warrants particular approbation.

The book throughout is well illustrated. Especially the section on cranial nerves has numerous well-selected photographs and the reproductions of roentgenograms in the section on intracranial tumors are splendid. Encephalography is well covered.

Because of its frank dismissal of the simple, and its emphasis on the broadest type of medical learning, it becomes more a book for graduate internists in medicine than for the beginner, either in medicine or neurology.

One might wish for a more flowing style. The author's ambition to quote every nuance of meaning in his exhaustive excursions into the literature, brings upon him a meticulous and, at times cumbersome sequence. At the same time, no one can find in it any of the glibness

which has occasionally characterized other textbooks in neurology, in the English language, on both sides of the Atlantic.

One can make small criticisms. Why is there no mention of arsenic poisoning as a likely etiology of some cases of Raynaud's disease? Why the use of the label "lethargic encephalitis" when American usage has generally and wisely changed to "epidemic encephalitis" since "lethargy" is often enough conspicuous by its absence.

In all, it is a weighty and substantial volume quite successful in being a well-planned statement of present-day organic neurology, and that brings the reviewer to a final and really serious contention regarding the book. This reference is to Grinker's willingness to call his book "Neurology" when there is neither a chapter nor reference to the psychoneuroses. Neurology, as a branch of medicine, has always dealt with both structural and functional nervous disorders, including the mental, and will continue to do so, in spite of the apparent willingness of some workers to circumscribe it. If the author had neither the space, the interest nor experience to describe the psychoneuroses, he would have done better to have chosen a title in which this artifical delimitation is explicit.

Thomas K. Davis

Books Received

The Clinical Management of Horseshoe Kidney: A study of horseshoe kidney disease, its etiology, pathology, symptomatology, diagnosis and treatment. By Robert Gutierrez, A.B., M.D., F.A.C.S., Chief of Clinic of the Department of Urology, James Buchanan Brady Foundation of the New York Hospital; Assistant Attending Surgeon, New York Hospital, etc. With a Foreword by Dr. Edmond Papin, Paris. Cloth. Price, $3.00. Pp. 143, with 52 illustrations. New York: Paul B. Hoeber, Inc., 1934.

Practical X-Ray Therapy. By Hugh Davies, M.A. (Oxon.), M.R.C.S. (Eng.), D.M.R.E. (Camb.), Officer-in-Charge of X-ray Therapy, King's College Hospital; Honorary Assistant Radiologist, The National Hospital, Queen Square. Cloth. Price, 8s. 6d. Pp. 134, with 47 illustrations. London: J. & A. Churchill, 1934.

Compendio di radiologia medica (radiodiagnostica e radioterapia) ad uso degli student e dei medici pratici. By Prof. G. B. Cardinale and Dott. Mario Maino. Paper. Pp. 493, with 330 illustrations. Milano: Ulrico Hoepli, 1934.

The Universe of Light. By Sir William Bragg, O.M., K.B.E., D.Sc., F.R.S., Honorary Fellow of Trinity College, Cambridge; Fullerian Professor in the Royal Institution of Great Britain. Cloth. Price, $3.50. Pp. 283, with 110 illustrations in the text and 26 plates. New York: The Macmillan Company, 1933.

Trattato di Roentgen- e di Curie-terapia. By Felice Perussia, Ordinario di Radiologia medica alla R. Universita di Milano, and Enzo Pugno-Vanoni, Straordinario di Elettrotecnica generale alla R. Scuola d'Ingegneria di Padova, and collaborators. Volumes I and II. Cloth. Price, L. 350. Pp. 1600, with 700 illustrations, Milano: Fratelli Treves Editori, 1934.

Die Krankheiten der Nasennebenhöhlen und des Ohres im Röntgenbild. Von Priv.-Doz. Dr. med. Richard Mittermaier, Oberarzt der Klinik. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Erganzungsband 45.) Paper, price M. 25.-; bound, M. 27.- Pp. 141, with 213 illustrations. Leipzig: Georg Thieme, 1934.

Die parasagittalen Meningeome. Von Dr. H. Olivecrona, Stockholm. Paper, price M. 24.-; bound, M. 26.- Pp. 144, with 145 illustrations. Leipzig: Georg Thieme, 1934.

Die endokrin und konstitutionel bedingten Anomalien des Knochensystems. By Prof. Dr. D. Rochlin, Institute of Roentgenology, Leningrad, U.S.S.R. Paper. Pp. 190, with 135 illustrations. 1931. (In Russian.)

Ionothérapie électrique et haute fréquence. Par François Fieschi, Chirurgien dentiste F. M. P. et E.D.F., Ingénieur A. et M., Professeur a l'école de Chirurgie dentaire et de Stomatologie de Paris. Paper. Price, 20 fr. Pp. 160, with 97 illustrations. Paris: Vigot Frères, Editeurs, 1933.

Trabalhos do Laborat rio de Medicina operatória. Faculdade de Medicina do Pôrto. Pp. 397, with numerous illustrations. Pôrto: Araújo & Sobrinho, 1932.

Annual Report of the Saskatchewan Cancer Commission for the Calendar Year 1932. Paper. Pp. 40. Regina: Roland S. Garrett, 1934.

Cent cas de Cancer Traités et Apparemment Guéris a l'Institut du Radium de Montréal. Dr. J. E. Gendreau, Directeur. Paper. Pp. 120. Montreal, Librairie Déom, 1934.

Medico-Military Symposium, 1934. Under the Auspices of the Kansas City Southwest Clinical Society and the Medical Department, Seventh Corps Area, U. S. Army. General Hospital, Kansas City, Mo., March 12–17, 1934. Kansas City, Mo.: Brown-White Co., 1934.

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DEPARTMENT OF TECHNIQUE

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A SIMPLE RADIUM DETECTOR*

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IT IS rather surprising that very few radium therapists have any kind of instrument for the location of lost radium, when the immediate availability of such an inexpensive instrument may prevent the permanent loss of thousands of dollars worth of radium. Regardless of how carefully radium is handled, circumstances can occur which are very embarrassing to the radiologist or the technician. At least once in my own experience such an instrument was the direct means of preventing the loss of 75 mg. of radium when the containers were accidentally stuck on a piece of adhesive, sent out with the trash, dressings and film papers, and spent the night in a garbage pile in the back yard. Within fifteen minutes after the radium was missed it was found through the timely efforts of the radium detector.

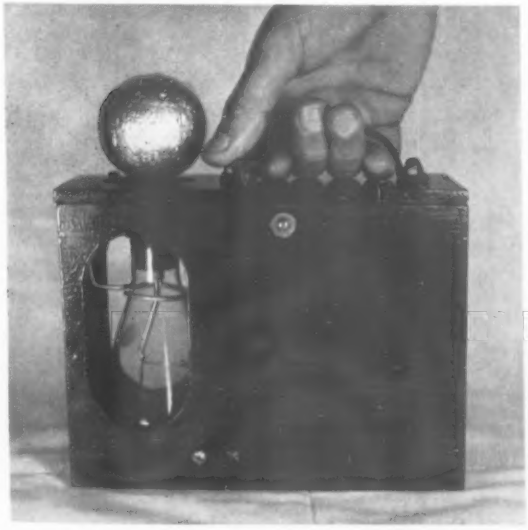

Fig. 1.

Fig. 2.

In reality this instrument consists of nothing but a simple uncalibrated gold leaf electroscope with some suitable charging device. Normally the electroscope holds its charge for many hours or even days under favorable conditions but when brought in-

Fig. 3.

* This paper was used as a part of the material submitted in application for degree of Master of Arts from the College of Charleston, Department of Physics, Horatio Hughes, M.A., Ph.D., Director.

to the vicinity of radioactive material it loses its charge with greater rapidity on account of the ionization in the surrounding air.

While the idea of this instrument is certainly not new, the device described here is so simple and inexpensive that its description may be warranted.

Figures 1, 2 and 3 show the instrument so completely that very little description is needed.

The electroscope is fairly large, as a small instrument is not as sensitive to small quantities of radiation. It is mounted in a glass flask about 4 inches in height, the gold leaf is about $1 \times \frac{1}{4}$ inch and the ball on top is a 2 inch cork fishing float coated with aluminum paint. The charging device is the same as that previously described [1,2] except that the old type of Ford spark coil is so difficult to obtain that the newer type without vibrator is used. From this coil one impulse is delivered when the primary circuit is closed and opened. A condenser is shunted across the contact points. A coil of this kind is unnecessarily large but it hardly seemed justifiable to go to the trouble of winding a special one.

Rough tests show that 1/13,000 r will produce an easily noticeable movement of the leaf; 50 mg. radium at 15 feet will do the same. Smaller amounts of radiation may be determined by timing the fall of the leaf.

It is reasonable to believe that if every owner of radium needles, tubes and plaques would equip himself with some kind of electroscope, losses could be reduced to the point which would justify the lowering of insurance rates.

[1] Taft, R. B. Charging device for electroscope. *Radiology*, 1926, *7*, 513–514.
[2] Taft, R. B. Modifications of electroscopic charging device. *Radiology*, 1929, *12*, 65.

AN OVERHEAD AERIAL HIGH TENSION SYSTEM

ESPECIALLY SUITABLE FOR SINGLE ROOM INSTALLATION*

By F. LIBERSON, M.D.
Roentgenologist, U. S. Public Health Service

THE recent advances in roentgen equipment increasing the safety of the high tension circuit by immersing the tube in the same case as the transformer, or by using flexible high tension insulating cables, fulfills satisfactorily the needs of a laboratory using only one tube for all its activities and makes unnecessary an aerial system in these installations. There is, however, still a need for an overhead high tension aerial in those single large-room installations where separate equipment for the special roentgen examinations (such as gastrointestinal, genitourinary, chest, sinuses, bones and joints) is placed individually in different parts of the room, each tube being energized by the same high tension generator. Such an aerial was designed by the author and four such aerials have been installed in the past five years at the Marine Hospitals, Hudson Street, New York, and Ellis Island, New York, and also in my private laboratory. Three of these were constructed by hospital mechanics. They have been so satisfactory and have stood the test of time so well that it is proposed to describe the aerial in detail here.

Essentially the aerial consists of a large loop of brass tubing attached by a "T" fitting to the generator anode high tension lead (Fig. 1). This loop, which is of such diameter as to come within 3 feet of the walls, is suspended from the ceiling by a number of insulating brackets and posts which attach on the inner aspect of the loop. This enables a single trolley wheel to be manipulated around the loop without

* Approved for publication by the Surgeon General, U. S. Public Health Service.

interference by the screws attaching the loop to the posts or by the brass tubing leading to the anode high tension terminal of the generator. Within this loop, suspended from the middle part of the brackets, either in the loop's long axis or at an oblique angle to it, are two brass tubes from 4 to 9 feet in length (depending upon the size of the room and the aerial) which run parallel except at the ends, where they are sharply curved in towards each other at almost a right angle, and are insulated (from each other) by bakelite pieces interposed between the ends (Fig. 2). One of these brass tubes is continued over the loop to the cathode end of the generator.

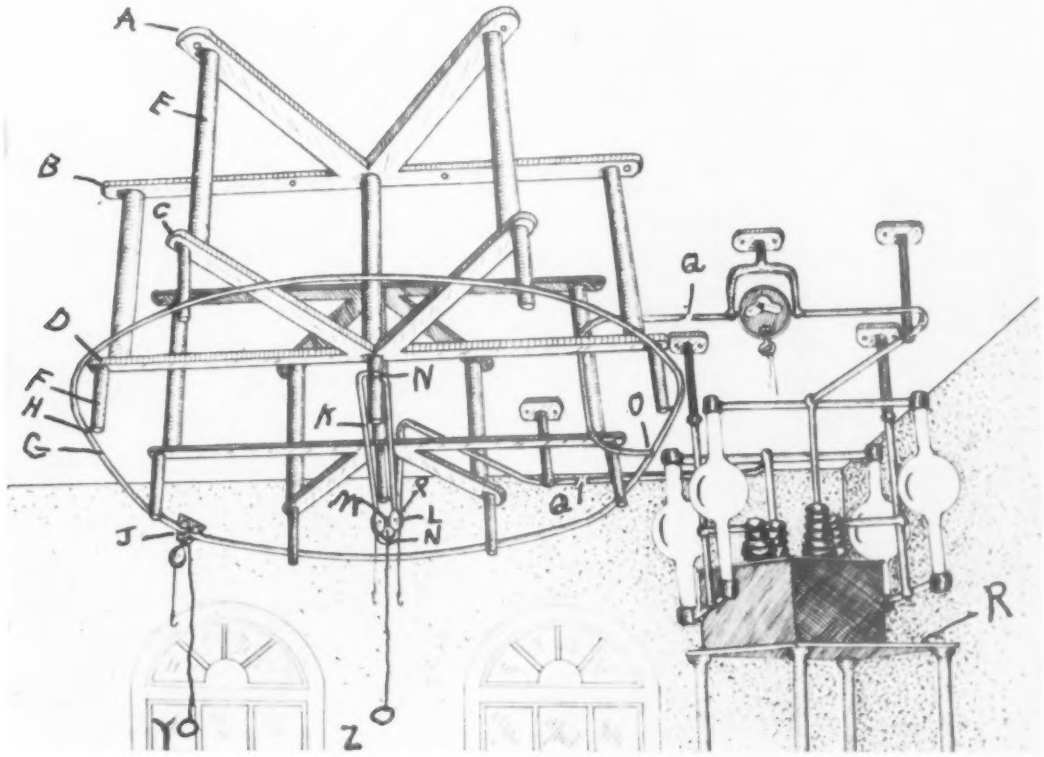

Fig. 1. This particular aerial is 9 feet long, and 6 feet wide. *A*. Ceiling bracket extending arm, 34′ long, 4″ wide, and 1″ thick. *B*. Ceiling bracket, main arm, 72″ long, 4″ wide, and 1″ thick. *C*. Suspension bracket extending arm, 36″ long, 2½″ wide, and 1½″ thick. *D*. Suspension bracket main arm, 74″ long, 2½″ wide, and 1½″ thick. *E*. Bakelite posts, 2′ long, 2″ in diameter. *F*. Bakelite posts, 8″ long, 1½″ in diameter. *G*. Continuous anode conduit, ¾″ brass tubing, attached to insulators, *F*, at *H* by a bolt with ½″ sleeve, to allow reel carrier, *J*, to pass all around conduit without interference. A firm contact of carrier *J* with the brass tubing is made by a spring-clamp, which can be released by a string attached, *Y*, when necessary to change its position. *K*. Cathode conduit, ¾″ brass tubing, attached to bakelite insulator posts as at *H*. Inserted in each curve *N* there is a piece of insulating material, preserving the continuity of the tubing so far as the high tension circuit goes, but creating the two filament conduits. The filament current wires are attached to each of the cathode conduits at *P*, and run back through tubing to transformer. *L*. Reel carriers, constructed the same as *J* except that they are fastened together by a baeklite plate. A string, *Z*, is attached to a spring-clamp on this plate to allow moving the reel carriers to any desired position on the conduits. *O*. Anode attachment of lead from transformer. *P*. Cathode attachment of lead from transformer. *Q*. Break in conduits, denoting that aerial can be placed at any desired distance from source of current supply. *R*. Attention is called to overhead transformer platform, insuring safety from high tension, and protection from breakage or rectifying tubes. This also affords space for control cabinet underneath, allowing short drop for transformer cables to control.

The cathode trolley wheels, which travel freely over these parallel tubes, move as a unit, being held together by a piece of insulating material.

The legend attached to the figures explains the construction of the aerial in detail. The materials required are as follows: Dried maple for the brackets; bakelite for the posts; $\frac{3}{4}''$ brass tubing for the loop and cathode conduit. The bakelite posts

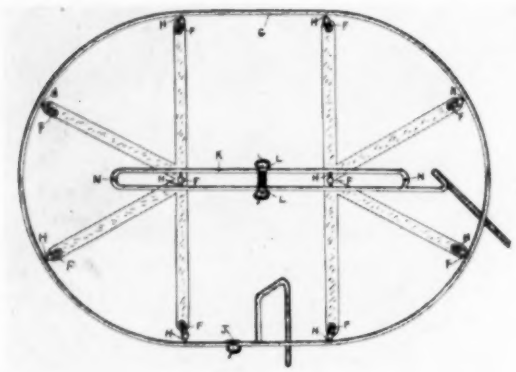

FIG. 2. A photodrawing of aerial as seen from the floor.

are of two sizes: the upper ones are from 2 to $2\frac{1}{2}''$ in diameter, and approximately $24''$ in length, or longer, depending on height of ceiling; the lower ones are from $1''$ to $1\frac{1}{4}''$ in diameter, and about $8''$ in length. The inner aspect of the brass tubing is attached to the bakelite posts by means of screws, with an interposed washer $\frac{1}{4}''$ long made of $\frac{3}{8}''$ brass tubing. The reel carriers and their spring clamps are described in the legend.

The advantages of this overhead high tension aerial which speak for its wide adoption in departments where roentgen apparatus is concentrated in a single room with two or more tubes, may be summarized as follows:

1. There are no extraneous trolley wheels or wires suspended from the aerial, which may be dangerous to those in the exposure room during an exposure or the testing of the machine. Both trolleys are always in use.

2. There is no possibility of coronal discharge or leakage from points of the aerial, since there are no ends to the positive or negative conduits.

3. Greater accuracy in the milliampere reading of the current which actually goes through the tube may be obtained, since the factor of leakage is eliminated.

4. There are no high tension switches.

5. There is not as much deposit of dust particles on the ceiling as with other overhead aerial high tension systems, so that the ceilings need not be painted as often.

6. The aerial is simple of construction, is inexpensive, and is of remarkably good appearance.

I wish to express appreciation to my assistant Winthrop D. Conklin for the photodrawings and cooperation in this work.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

Elsberg, C. A.: The meningeal fibroblastomas on the under surface of the temporal lobe, and their surgical treatment... 695

Mayer, E. G.: The roentgen diagnosis of hypophyseal tumors... 695

Davidoff, L. M., and Dyke, C. G.: An improved method of encephalography... 696

Rawak, F.: The differential diagnosis by encephalograms... 696

Neck and Chest

Györgyi, G.: The diagnostic importance of the filling of pharyngeal pouches... 696

Velde, G.: Roentgen appearance of accessory lower lobe of the lung... 697

Pohl, R.: The posterior lobe of the lungs... 697

Rieder, H.: A historical review of the question of the roentgenologic demonstration of cavities caused by destruction of the lungs in early tuberculosis... 697

Salinger, H.: Bone formation in the lungs, with special reference to the pseudotuberculous type... 697

Wilke, A.: Study of the heart by roentgen kymography... 697

Saul, W.: Densities in the heart shadow... 698

Pape, R.: Abnormal situation of the mesaortitic descending aorta... 698

Wolf, A.: The anteroposterior roentgenologic appearance of the heart as a basis for estimating enlargement of particular cardiac regions... 698

Everbusch, G., and Weltz, G. A.: Adhesions and folds of the diaphragm... 698

Abdomen

Johnston, C. G., and Brown, C. E.: Studies of gall-bladder function. III. A study of the alleged impediment in the cystic duct to the passage of fluids... 698

Eliasz, E.: Recent conceptions of the roentgenologic tests of the function of the gall-bladder... 699

Haring, W., and Horsters, H.: The roentgenographic appearance and chemical composition of gallstones... 699

Sandera, R.: True duodenum inversum; a typical variation in position of the duodenum... 699

Bársony, T., and Koppenstein, E.: Pointed diverticula of the fundus of the stomach... 700

Biedermann, F.: Spasm of the ceco-colic sphincter... 700

Rankin, F. W., and Major, S. C.: Surgical treatment of tuberculosis of the large bowel... 700

Genitourinary System

Stein, A., and Rodgers, M.: The influence of gynecological conditions on the genitourinary tract as shown by simultaneous injections of skiodan or uroselectan (intravenously) and lipiodol... 701

Skeletal System

Geipel, P.: The recognition of spina bifida of the atlas and axis. Part II... 701

Reed, Edward N.: A case of complete dislocation between the fifth and sixth cervical vertebrae, without fracture... 701

Goette, K.: A form of spondylarthropathy of the cervical spine with radicular disturbances... 702

Niedner, Franz: A contribution to the knowledge of the normal and pathologic anatomy of the contours of the vertebral bodies... 702

Mardersteig, K.: Concerning persistent apophyses of the vertebral column... 702

Rathcke, L.: Calcareous deposits in the intervertebral discs... 703

Chasin, Adib: Changes in the spine after tetanus... 703

Kühne, K., and Gerstel, G.: Clinical, roentgenological and pathologico-histological findings in a case of generalized osteophytosis... 703

Van Alstyne, G. S., and Gowen, G. H.: Osteitis tuberculosa multiplex cystica (Jüngling)... 703

Cone, S. M.: Paget's osteitis deformans in relation in cardiovascular disease... 704

Compere, E. L.: The role of the parathyroid glands in diseases associated with demineralization of the human skeleton... 704

Ballin, Max: Parathyroidism in reference to orthopaedic surgery... 705

Bauer, W.: Hyperparathyroidism; a distinct disease entity... 706

Funsten, R. V.: Certain arthritic disturbances associated with parathyroidism... 708

Nachlas, I. William: Considerations on the use of parathyroidectomy for arthritis... 708

Buschbeck, H.: Contribution to our knowl-

edge of the roentgen visibility of shadows in the femoral spongiosa 709
FABER, A.: Dislocation of the astragalus 709
ROBERTSON, R. C., and BOGART, F. B.: Fracture of the capitellum and trochlea, combined with fracture of the external humeral condyle 709
PEABODY, C. W., and MURO, F.: Congenital metatarsus varus 709
FERGUSON, A. B.: Short metatarsal bones and their relation to poliomyelitis 710
CLARK, D. F., and QUINT, H. A.: Dislocation of a single cuneiform bone 710
BUCHMAN, J.: Osteochondritis of the internal cuneiform 711
JENKINS, H. P., and DELANEY, P. A.: Benign angiomatous tumors of skeletal muscles .. 711
STRAUS, F. H.: Marching fractures of metatarsal bones 712
KRAFT, E., and KATO, K.: Roentgen findings in lead poisoning in children 712

ROENTGEN AND RADIUM THERAPY

WINTZ, H.: Disputed questions in regard to temporary amenorrhea from irradiation .. 712
LUXENBURGER, H.: Temporary sterilization by irradiation and research in human heredity 712
MAURER, E.: Examinations of children whose mothers have been irradiated 713
NÜRNBERGER, L.: The resolution of the German Society for Research in Heredity in regard to late injury by roentgen rays and its consequences for radiotherapy 713
DYROFF, R.: Comparative histology of the ovaries in relation to the question of injury of germ plasm by roentgen rays 714
NEEFF, TH. C.: The problem of dosage in temporary sterilization by irradiation 714
ALBRECHT, HANS: Clinical experience with temporary roentgen amenorrhea 714
v. KRENNINGER-GUGGENBERGER, J.: The estrus as a sign of the beginning of ovulation after temporary roentgen sterilization 715
BORAK, J.: On the possibility and probability of injury to the germ cell after irradiation of the ovaries 715
DRUCKMANN, A.: Retrogression of an exostosis under roentgen irradiation 715
BUTLER, C.: Treatment of Basedow's disease with radium and its results 716
BORAK, J.: Relations between the radiosensitiveness of malignant tumors and their mother tissue 716
NEMENOW, M.: Tumors of embryonic structure—embryocytomas—and their radiosensitiveness 716
DUFFY, J. J.: Carcinoma of the tonsil 717
BURNAM, C. F.: Diagnosis and treatment of malignant tonsil conditions 718
NEW, G. B., BRODERS, A. C., and CHILDREY, J. H.: Highly malignant tumors of the pharynx and base of the tongue 719
STÄHLER, F.: A new aiming instrument to make focusing easier in gynecological deep irradiation 719
SCHMITT, W.: Results of operation and irradiation in cancer of the cervix 719

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Elsberg, Charles A. The meningeal fibroblastomas on the under surface of the temporal lobe, and their surgical treatment. *Bull. Neurol. Inst. New York*, March, 1932, *2*, 95–118.

Of 102 meningeal fibroblastomas in the author's series of 767 verified tumors of the brain, 15, or 14.7 per cent, lay on the under surface of the temporal lobe and were attached to the dura of the floor of the middle cranial fossa. They were usually encapsulated. Meningeal fibroblastomas increase in size very slowly.

Clinical symptoms were convulsive seizures, usually generalized, occurring in 12 of the 15 cases; homonymous hemianopsia occurred in 4 patients; the visual field was contracted in 10 patients and in 4 the blind spots were enlarged; nystagmus occurred in 9 patients; visual hallucinations occurred in 2 patients; papilledema was frequently seen. Unilateral facial weakness is not an important sign. The symptoms and signs are often vague, localization roentgenologically often being necessary.

Thirteen of the above 15 patients were examined roentgenologically; there was an atrophy of the floor of the sella tursica in 9 due to an increase in the intracranial pressure. Changes in the sphenoid ridge were found in cases in which the tumor occurred interiorly in the middle fossa. Other diagnostic features are hyperostosis, erosion or calcification within the tumor. Ventriculography produces displacement of the ventricular system which is diagnostic.—*J. H. Vastine.*

Mayer, Ernst G. Über die röntgenologische Diagnose der Hypophysentumoren. (The roentgen diagnosis of hypophyseal tumors.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1932, *46*, 497–519.

Enlargement and erosion of the sella turcica occurs in tumors of the sellar region, hydrocephalus of the third ventricle with accumulation of fluid in the cysterna chiasmatis, in senile atrophy of the skull, luetic disease of the pituitary, in cretinism, in eunuchoidism, in neurofibromatosis and in cases of atrophy of the anterior lobe of the pituitary of uncertain origin. Hydrocephalus and neoplasm should be considered first of all in a case of erosion of the sella turcica. It is difficult to detect early enlargement of the sella because of the normal variations in its size. It is of great importance diagnostically to distinguish between direct erosion due to tumor and indirect erosion due to hydrocephalus. The differential diagnostic points stated by Stenvers are incorrect and are generalizations from isolated cases. In hydrocephalus of the third ventricle the sella turcica shows either a general distortion of the bones or localized defects or a diffuse osteoporosis of certain regions. If there is erosion of the sella which is caused directly by a tumor, then it is possible to determine the primary site of the tumor, that is, whether it is endo- supra- para- or infrasellar. Abnormal calcification of the sella turcica region definitely favors, direct erosion from tumor. The type of enlargement of the sella, whether it is regular or irregular, is of no direct significance in differential diagnosis. In the differential diagnosis the relationship of the dorsum sellae, the tuberculum sellae and the clinoid processes and the absence of calcification are of particular importance. The floor of the sella is of importance because asymmetrical enlargement is present only in exceptional cases when indirect erosion occurs. Enlargement laterally due to endosellar tumors is usually more regular than in the case of hydrocephalus and early loss of distinctness of the floor of the sella as seen in the roentgenogram is more commonly found in hydrocephalus than in tumors. In primary intrasellar tumors the mouth of the sella is relatively little changed while with tumors of suprasellar origin it is the first region to be changed. Calcifications of the dura may present interesting points in differential diagnosis. Parasellar tumors erode the sella to the greatest degree, and not always symmetrically. They often lead to marked changes in the alae of the sphenoid, which is not the case with pituitary tumors. Flat flaky calcifications, if not related to the dura, favor a cystic lesion, especially if they are at the periphery of the tumor. Centrally

situated flaky calcifications favor solid tumors. Infrasellar tumors are generally malignant and rapidly destroy the body of the sphenoid and may also lead to changes in the accessory sinuses. The author presents reproductions of the roentgenograms illustrating the various types of sellar lesions.—*E. T. Leddy.*

DAVIDOFF, LEO M., and DYKE, CORNELIUS G. An improved method of encephalography. *Bull. Neurol. Inst. New York*, March, 1932, *2*, 75–94.

Encephalography has become an indispensable adjunct to neurological diagnosis. Following Dandy's introduction of this procedure in 1919, the method of introducing air through the lumbar route (encephalography) was little utilized until 1925 when its value was emphasized by Foerster, Wartenburg, Friedman, Fay, Pancoast, Pendergrass, and others. Ventriculography is the safer procedure in cases with increased intracranial pressure, whether due to tumor or some other cause. The disadvantages of ventriculography are that it is a relatively major surgical procedure, that it involves a certain amount of trauma to the brain, and that by the direct injection of air the ventricles alone are usually outlined. By encephalography air may enter any region of the cranial cavity which is occupied by cerebrospinal fluid. Moreover, with a little experience the procedure can be carried out by anyone capable of performing a lumbar puncture. Signs of increased intracranial pressure, in the presence of which encephalography is not performed, are papilledema, vomiting and headache, convolutional markings, separation of the sutures and pressure atrophy of the sella turcica. These signs are considered more reliable than measurement of the spinal pressure in millimeters of mercury which is subject to considerable variation in the individual case.

The authors describe the technique employed by them, the chief departure of which is the making of a single film after removal of 25 c.c. of cerebrospinal fluid and injection of 20 c.c. of air, thus enabling them to know whether the ventricular system is normal in size or whether it is dilated. The amount of air necessary can thus be approximated, 50 to 70 c.c. of air being sufficient if the ventricles are normal in size. The distressing symptoms vary according to the amount of air used relative to the size of the ventricles. They state that it is possible to obtain good encephalograms with much less air than is usually introduced and thereby to materially decrease the discomfort to the patient.—*J. H. Vastine.*

RAWAK, F. Zur Differentialdiagnose des Enzephalogramms. (The differential diagnosis by encephalograms.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1932, *46*, 520–529.

The cases described by the author illustrate how an encephalogram may make a diagnosis in some cases in which neurologic signs are obscure or are lacking. Encephalography may not only confirm the diagnosis of cerebral tumors but also definitely exclude one which is often of great importance. Rawak feels that encephalography should be used more frequently in differential diagnosis of lesions of the midbrain. In his experience it was impossible to differentiate the various types of hydrocephalus.—*E. T. Leddy.*

NECK AND CHEST

GYÖRGYI, GÉZA. Die diagnostische Bedeutung der Pharynxtaschenfüllung. (The diagnostic importance of the filling of pharyngeal pouches.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 422–427.

The diagnosis of the condition dysphagia atonica described by Holzknecht and Olbert depends on a permanent filling of the pharyngeal pouches after swallowing a mouthful of thick barium. The author found filling of these pouches in 22.8 per cent of the 250 cases he examined. In some cases the filling was due to local changes in the pharynx and larynx; in others it was due to esophageal carcinoma, diverticula, etc., and their disturbing action on the innervation of the pharyngeal musculature, or pressure on the vagus nerve or its branches. Organic nervous disease in which there is dysphagia may show the same symptom. In other cases where there are local anatomical changes in the pharynx the filling may be due to changes in the normal tonus of the sympathetic nervous system. Dysphagia atonica is a valuable indirect sign of many organic pharyngeal and esophageal lesions. Its investigation, during which many manifest and latent difficulties in swallowing may be brought to light, is easily carried out, and should not be omitted in any thoracic or gastric examination. —*E. T. Leddy.*

Velde, G. Der Lobus inferior accessorius im Röntgenbild. (Roentgen appearance of accessory lower lobe of the lung.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1932, *46*, 588–596.

This accessory lobe occurs usually on the anterior medial aspect of the lower lobes; it may be on the right or left side; in many cases there is complete formation of an accessory lobe, in other cases only partial. Its size is quite variable and therefore the course of the interlobar septum is very variable. The shadow of this structure must be differentiated from that of encapsulated paramediastinal pleuritic exudate. If infiltration is not present and only a linear shadow can be seen, the occurrence of a pleuritis secondary to abdominal disease must be considered. The author reports 2 cases and states that it is difficult to determine the commonness of this malformation but in 3,200 thoracic films he found 39 cases of lobus inferior accessorius, or 1.2 per cent, and his cases occurred more frequently on the right side.—*E. T. Leddy.*

Pohl, R. Der Lobus posterior der Lunge. (The posterior lobe of the lungs.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1932, *46*, 583–587.

This condition which is an abnormal partition of the lower lobe of the lung occurs only on the right side. The apex of the lower lobe is more or less completely separated into lobes. It can be visualized only when it or the neighboring interlobar spaces are involved in some pathologic process. The lobe is occasionally found at autopsy but uncommonly by roentgenography so the author feels that a knowledge of this lobe may help to clear up the diagnosis of certain obscure pulmonary lesions.—*E. T. Leddy.*

Rieder, H. Ein historischer Rückblick auf den röntgenologischen Nachweis von Destruktionskavernen bei Anfangstuberkulose der Lungen. (A historical review of the question of the roentgenologic demonstration of cavities caused by destruction of the lungs in early tuberculosis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1932, *46*, 621–627.

In the years 1908 to 1910 Rieder reported that cavities in the lung did exist in early tuberculosis, which although demonstrable roentgenologically could not be discovered by percussion or auscultation. He offered proof for this view before the Sixth Roentgen Congress in Berlin in 1910. At that time his roentgenologic demonstration received little support because the Congress was unwilling to admit that the changes he showed in the roentgenograms were due to cavities. In spite of this, Rieder maintained his view which he published in the Proceedings of the German Roentgen Society, volume 6, under the title "Cavities in early tuberculosis.' In recent years many others have described these roentgenologic signs as "new discoveries." The author therefore would like to make a definite claim for priority and, to support it, reproduces the films he showed in 1910. All show early stages of tuberculosis with cavities caused by destruction of the lung.—*E. T. Leddy.*

Salinger, Hans. Die Knochenbildungen in der Lunge mit besonderer Berücksichtigung der tuberösen Form. (Bone formation in the lungs, with special reference to the pseudotuberculous type.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1932, *46*, 269–275.

Pseudo-tuberculous forms of bone formation in the lung must be distinguished from the lattice and diffuse type. The first are due to chronic stasis while the lattice type is due to malformation of tissues. In all reported cases which had massive tubercular bony deposits there was a mitral stenosis.—*E. T. Leddy.*

Wilke, Adolf. Untersuchungen an Herzen mittels Röntgenkymographie. (Study of the heart by roentgen kymography.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1932, *46*, 558–570.

Kymography produces an image of the heart which allows the differentiation of the various contours of the auricles, ventricles, and vessels by the type of their respective motions. As a result the analysis of particular parts of the contour of any cardiac region is improved and knowledge is obtained of the displacement of particular cardiac regions, relative to each other. In certain cases it is possible to obtain definite data from the visible changes in the relationship of auricle and ventricle, about the functional capacity of the heart and whether the variations are due to organic or functional causes, even when the size of the whole heart shadow is normal. Studies of the heart in

motion give information about the amplitude of pulsation, variations in the movements, and about disturbances in rhythm. In some cases the study may give definite information about the presence or absence of aneurysm and tumor. —*E. T. Leddy.*

SAUL, WALTER. Verdichtungen im Herzschatten. (Densities in the heart shadow.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 450–457.

Densities in the heart shadow may be chiefly attributed to extracardiac formations. The most common cause of the shadows which are superimposed on the heart shadow are calcareous deposits in the annulus fibrosus and the pericardium. Their differential diagnosis from other calcifications is discussed on the basis of 4 cases.—*E. T. Leddy.*

PAPE, R. Über einen abnormen Verlauf ("tiefe Rechtslage") der mesaortitischen Aorta descendens. (Abnormal situation (right transverse position) of the mesaortitic descending aorta.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1932, *46*, 257–268.

Pape reports 3 cases in which the descending aorta at its middle third was displaced to the right side of the thorax. All three showed changes from the simple S-form of the arch of the descending aorta to a high degree of aneurysm. The cause of this abnormal curvature is the high degree of mesaortitis, longitudinal extension of the aorta and an abnormal elasticity of the various parts of the vessel wall which favor the occurrence of an S-form. The roentgen appearance of the lesion is characterized by (1) an abnormally convex shadow of the right arch behind the heart, (2) a sudden shift of the descending aorta towards the left side, and (3) by a shortening of the intermediate transverse arch shown by a transverse shadow in the right semi-oblique position and by simultaneous filling of the esophagus.—*E. T. Leddy.*

WOLF, ARTUR. Das frontale Herzbild als Mittel zur Beurteilung der Vergrösserung der einzelnen Herzabschnitte. (The anteroposterior roentgenologic appearance of the heart as a basis for estimating enlargement of particular cardiac regions.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1932, *46*, 275–281.

On anteroposterior screen examination the posterior angle which is made with the diaphragm is filled by the shadow of the vena cava. The posterior side of this shadow, which is triangular, is formed by the vena cava, the upper by the left ventricle and the lower by the diaphragm. In the normal heart this triangle is equilateral, the sides being 2.3 cm. long. When the left ventricle is enlarged (usually from behind downward) the cava side of the triangle is shortened and when the enlargement is of a high degree, disappears entirely within the heart shadow. The cava shadow can therefore be used to measure the degree of expansion of the left ventricle. Enlargement of the right ventricle is from before upward, so that the heart outline lies above the sternum. With these variations typical cardiac appearances occur. The normal heart shows a small oval, the aortic heart shows a semispherical outline, the mitral stenotic heart a spherical form and the heart with mitral regurgitation a wide oval. —*E. T. Leddy.*

EVERSBUSCH, G., and WELTZ, G. A. Über Zwerchfelladhäsionen und Zwerchfellfalten. (Adhesions and folds of the diaphragm.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1932, *46*, 282–286.

Atypical irregularities of the diaphragm and the formation of folds (particularly those of the thoracic type) may easily be confused with adhesions. Folds also occur in pneumothorax which shows that the ways in which folds and adhesions form are quite different. The authors discuss briefly some of the appearances of these folds.—*E. T. Leddy.*

ABDOMEN

JOHNSTON, C. G., and BROWN, C. E. Studies of gall-bladder function. III. A study of the alleged impediment in the cystic duct to the passage of fluids. *Surg., Gynec, & Obst.*, March, 1932, *54*, 477–485.

There are those (Sweet, Halpert, Bland, Demel, and Brummelkamp) who believe that the contents of the gallbladder are removed without passing back through the cystic duct. The great majority of investigators, however, believe that, although the absorption of certain constituents does take place through the gallbladder lymphatics or blood vessels, the concentrated bile leaves the gallbladder through the cystic duct to enter the duodenum as the result of certain physiological stimuli.

Sufficient evidence has accumulated that one

may say with little reservation that the gallbladder does, under certain conditions, empty its contents. Strips of the gallbladder wall have been shown to contract (Lieb and McWharter, Ravidin and Morrison). The isolated bladder has been shown to respond to drugs which stimulate smooth muscle contraction (Ravidin and Morrison). For the bile from the gallbladder to reach the duodenum by the ductal route, it must pass two possible obstructions, the cystic duct, with its valves of Heister and its cystic kink, and the sphincter of Gage and Oddi. McMasters and Elman, working with live dogs, unanesthetized, and fully recovered from operative effects, report definite spurts of bile from a tube connected to a cannula in the cystic duct, following a meal. They obtained cystic pressures as high as 260 mm. of bile. They also found that it required a pressure of 100 mm. of bile, or more, to cause bile to flow into the duodenum from the common duct. Thus, it has been shown that the gallbladder contracts and that sufficient pressure is induced to force bile through the sphincter of Gage and Oddi. Johnston and Brown, in an effort to further substantiate the belief that the gallbladder does empty through the cystic and common ducts into the duodenum, have experimented on 7 living dogs and on freshly removed gallbladders from the human cadaver. They could find no impediment to the passage of fluid through the cystic duct at pressures usually found in the biliary tract. The authors do not discuss Whitaker's work on cats, in which he roentgenoscopically observed iodized oil to pass from the gallbladder through the ducts into the duodenum.—*J. H. Vastine.*

Eliasz, Ernst. Neuere Gesichtspunkte bei der röntgenologischen Funktionsprüfung der Gallenblase. (Recent conceptions of the roentgenologic tests of the function of the gallbladder.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 402–413.

Eliasz states that the gallbladder may show simultaneously multiple and varying concentrations so that specimens of the so-called A-bile may under certain circumstances be obtained when the gallbladder is emptied by means of a duodenal sound. The gradual darkening of the bile from the duodenal sound may also be accounted for by different concentrations of bile. He feels that the formerly held view that with a thickened gallbladder wall the concentration of bile is always low is not correct. He assigns to the deposition of bile on a thickened gallbladder wall some hitherto completely unexplained part in the formation of gallstones.—*E. T. Leddy.*

Haring, Wilhelm, and Horsters, Hans. Röntgenbild und chemische Zusammensetzung von Gallensteinen. (The roentgenographic appearance and chemical composition of gallstones.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1932, *46*, 546–553.

Various types of gallstones were photographed, then roentgenographed first in air and then in artificial bile and in tetraiodophenolphthalein. Then each stone was analyzed chemically. Comparison of the roentgenograms and the chemical composition of the stones confirmed the well-known fact that roentgenographic density increases with the inorganic material in the stones, particularly the calcium content. Cholesterin stones are clear when placed in bile or in an opaque substance (negative stone shadows). Calculi made of pigment salts gave somewhat denser shadows than cholesterin stones. Radiating circular cavities in the stones were due to contraction from drying and were easily shown in the roentgenograms. Chemically, phosphates were found more often than has been assumed. It was interesting to note the small gallic acid content and that of the salts of gallic acid, the percentage of which in the bile is 8 to 10 per cent. This may be due to the fact that free gallic acid salts in the gallbladder markedly suppress the expulsion of bile through a hormonal nervous effect.—*E. T. Leddy.*

Sandera, Robert. Das echte Duodenum inversum. Eine typische Lagevariation des Duodenum. (True duodenum inversum. A typical variation in position of the duodenum.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1932, *46*, 576–582.

In a previous paper Sandera proposed to classify congenital duodenal dystrophies in three groups in relation to causation and roentgen signs as follows: (1) Duodenum mobile totale, (2) duodenum mobile inversum, and (3) duodenum partim mobile. In the group duodenum mobile inversum a transitional type was found which the author calls true duodenum inversum. Of the 7 cases reported by the author, 2 showed, at operation, anatomical

variations which he regards as typical. In these cases the duodenum is inverted and surrounds an abnormally shaped head of the pancreas lying totally above the transverse mesocolon. The changes in position of the duodenum are probably congenital. The paper has a detailed consideration of the clinical and roentgen aspects of the lesions.—*E. T. Leddy.*

BÁRSONY, T., and KOPPENSTEIN, E. Spitzendivertikel des Magenfundus. (Pointed diverticula of the fundus of the stomach.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 414–422.

Pointed diverticula are a special group of the diverticula in the cardiac end of the stomach. They are separated by a circular filling defect from the rest of the stomach and give a typical roentgen picture. The outlines of the diverticula are continuous with the contour of the stomach and are broken in contour by circular contractions. The analogy with the diverticula of the human gallbladder and the gastric diverticula of hogs suggests that they are congenital lesions and do not cause severe difficulty symptomatically. Roentgenologically they cannot be confused with other conditions in the stomach.—*E. T. Leddy.*

BIERDERMANN, FRITZ. Über Spasmen am zökokolischen Sphinktertrakt. (Spasm of the cecocolic sphincter.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1932, *46*, 670–679.

The author discusses the morphology, causes, effects and clinical aspects of spasm of the cecocolic sphincter. He calls attention to the pain this lesion produces and which causes the patient to seek medical advice. Unless roentgen examination is carried out errors in diagnosis may be committed.—*E. T. Leddy.*

RANKIN, FRED. W., and MAJOR, S. G. Surgical treatment of tuberculosis of the large bowel. *Surg., Gynec, & Obst.*, Oct., 1932, *55*, 494–501.

Two types of tuberculous lesions occur in the large and small bowels: the first type, and the one most satisfactorily treated surgically, is hyperplastic tuberculosis, or so-called tuberculoma, and the second is tuberculous ulcerative colitis, usually a widespread condition. Coexisting lesions of the thorax are common in the latter condition. Pulmonary tuberculosis was much less frequent in the hyperplastic type of tuberculosis, the thorax being roentgenologically negative in 56 per cent of the authors' cases.

Hyperplastic tuberculosis occurs most frequently in middle life, the average age of 65 cases being thirty-five years. The ileocecal region is the site of election. Extreme chronicity of the disease, without sufficient incapacitation to demand early relief is characteristic. The average duration of symptoms in the authors' cases was over four years.

Symptoms: pain, most pronounced following meals and usually relieved by vomiting or evacuation; loss of weight, progressive over a rather long period; diarrhea, usually periodic, hemorrhage rarely. A tender, fixed mass can usually be palpated in the right ileocecal region which is doughy in consistency as contrasted with the hard indurated mass of carcinoma.

Diagnosis of the hyperplastic type of tuberculous colitis may be made roentgenologically by eliciting evidence of local hypermotility with filling defects, the filling defects being the special manifestation. Stierlin's sign is present in any type of ulceration of the colon, benign or malignant.

The hyperplastic type of tuberculous colitis (tuberculoma) must be differentiated from carcinoma, actinomycosis, localized chronic ulcerative colitis and the deformity produced secondary to pericecal abscesses, usually appendicial.

The ulcerative type of tuberculous enterocolitis is characterized by extensive diffuse narrowing, loss of haustra, and evidence of mucosal destruction with coexisting pulmonary tuberculosis as is frequently present in this type of intestinal tuberculosis. Differentiation must be made between tuberculous ulcerative colitis, amebic colitis, and chronic ulcerative colitis. Chronic ulcerative colitis characteristically begins in the rectum and progresses proximally; amebic ulcerative colitis and tuberculous ulcerative colitis, on the other hand, begin in the cecum and progress distally. The presence of tuberculous colitis is postulated or ruled out by the condition in the thorax. The comparatively mild form of amebic colitis seen in northern latitudes has a roentgen appearance similar to that of chronic ulcerative colitis in that the affected portion of the colon is hyperirritable, the haustra are subdued, and signs of mucosal destruction are present; the colon

preserves its pliability, thickening of the wall is not so severe, peristalsis is not interfered with so markedly, and the entire process does not give the impression of the severity observed in chronic ulcerative colitis.

The ulcerative type of tuberculosis of the intestine is not suited to surgical treatment due to the extensive involvement. Very gratifying results are obtained by radical resection of the tuberculous tumor in the hyperplastic type of the disease.—*J. H. Vastine.*

GENITOURINARY SYSTEM

Stein, Arthur, and Rodgers, Mortimer. The influence of gynecological conditions on the genito-urinary tract as shown by simultaneous injections of skiodan or uroselectan (intravenously) and lipiodol; a preliminary report. *Surg., Gynec. & Obst.*, Oct., 1932, *55*, 490–493.

Simultaneous uterosalpingograms and intravenous urograms were made on 11 patients in an effort to demonstrate the relation between changes along the female urinary tract and physiological tumors, such as pregnancy and pathological conditions, such as fibroid tumors or ovarian cysts. All of the cases of pregnancy (5) in which this procedure was undertaken had been admitted for therapeutic interruption and so there was no hesitancy about injecting the uterus. In none of the patients, whether the stage of gestation was as early as six weeks or as late as six months, were uterine contractions noted or was any attempt made to expel the fetus; nevertheless, the authors would not do uterosalpingography in cases in which the pregnancy was expected to continue. Intravenous urography is not contraindicated in pregnancy.

A dilatation of both ureters was observed in all pregnancy cases even as early as six weeks, this dilatation increasing with the period of gestation. On the other hand, with uterine myomata of a corresponding size no similar dilatation of either the kidney pelves or ureters was found. It was therefore concluded that the dilatation of the ureters in pregnancy is a purely physiological process, while a pelvic tumor of a corresponding size, whether a fibroid or a cyst, is incapable of producing, by mechanical means alone, a similar condition. It is well to remember this physiological dilatation of the ureters in pregnancy that it may not be mistaken for a pathological process.—*J. H. Vastine.*

SKELETAL SYSTEM

Geipel, P. Zur Kenntnis der Spaltbildung des Atlas und Epistropheus II. Teil. (The recognition of spina bifida of the atlas and axis. Part II.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 373–402.

The author discusses 35 cases of spina bifida of the atlas which occurred in 1,136 necropsies, an incidence of 30 per cent. Besides posterior medial spina bifida there occurred also defects in the anterior arch and in the posterior lateral arches. He also describes 4 cases of defect in the axis, and points out the frequency with which defects occur in the atlas in contrast with the other vetebrae.—*E. T. Leddy.*

Reed, Edward N. A case of complete dislocation between the fifth and sixth cervical vertebrae, without fracture. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 235–236.

Reed states that complete dislocations between vertebrae, without fracture, are infrequent, and in the cervical vertebrae they are usually fatal. The case he reports is of interest because of the complete dislocation without fracture, and because, in spite of severe cord damage, the patient not only survived but recovered a considerable amount of cord function.

The patient was a young married woman aged twenty-three, who while playing on the beach was lifted up and came down on the top of her head, with her neck sharply flexed forward. She was immediately paralyzed in all extremities. The paralysis was at first spastic but in a few hours it became flaccid. Roentgenograms of her cervical spine showed an almost complete dislocation of the fifth cervical forward on the sixth. There was no evidence of fracture.

The dislocation was reduced on the day following the accident by traction and manipulation, with the patient under anesthesia. A head harness was applied with two pounds of traction weight. On the day following the reduction there was a recurrence of the dislocation as shown by roentgenograms. The dislocation was again reduced.

The head traction with two pounds of weight, was kept on for four weeks followed by a Thomas collar for two months. In spite of scrupulous care, the patient developed an ulcer over the sacrum which was healed at the end of six months. At the end of two months there

were still increased reflexes in all four extremities with ankle clonus and Babinski reflexes on both sides. All deep reflexes had been lost. There was also considerable motor return in the upper extremities and beginning of motion in the legs, with good tactile sensation and some pain and temperature sensation in all four extremities. Control of bladder and rectum were still lost at the time of the last check-up. Also marked incoördination and muscular overaction in the lower extremities were present. In the upper, coördination was fairly good. The patient could write a little, and sensation was good. She was also beginning to walk a little.

In the lower extremities, from the suprapubic region downward, tactile sensation had returned but there was no pain or temperature sensation. —*R. S. Bromer.*

GOETTE, K. Über eine Form der Spondylarthropathie der Halswirbelsäule mit radikulären Störungen. (A form of spondylarthropathy of the cervical spine with radicular disturbances.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1932, *46*, 691–701.

In the case reported by the author there was a spondylarthritic deformity, the cervical vertebrae were narrowed and intervertebral defects appeared. The fourth to eighth cervical nerves were affected and gave rise to sensory and motor disturbances, changes in the reflexes, and muscular atrophy.—*E. T. Leddy.*

NIEDNER, FRANZ. Zur Kenntnis der normalen und pathologischen Anatomie der Wirbelkörperrandleiste. (A contribution to the knowledge of the normal and pathologic anatomy of the contours of the vertebral bodies.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1932, *46*, 628–662.

According to Schmorl, vertebral epiphyses do not have an enchondral growth, unlike those of the long bones. From calcified foci which are deposited at the vertebral angles of the cartilaginous strips in an irregular manner in the seventh year of life, the bony nuclei of the borders are developed. These enlarge, but to a lesser degree than the vertebral growth. At the twenty-fifth year these vertebral epiphyses are united to the vertebrae. They exist in the vertebral borders as small rings about 1.2 mm. high and 2.9 mm. wide. They are infiltrated by the fibers from the annulus and in this manner allow resistance to pressure or strain on movement transmitted to them by the intervertebral discs. They are important with respect to the function, rather than the growth and development of the vertebrae. Those diseases which affect the epiphyses of other bones do not affect the vertebral border epiphyses. This is particularly the case in regard to the so-called "persistent epiphyses" which have been described by many authors. The absence of union of these epiphyses and the vertebra (or the persistence of an epiphyseal line) is found only in two endocrine diseases, endemic cretinism and Paltauf dwarfs. In these diseases, however, a quite different picture is found from that described as "persistent epiphyses." Other than in the two diseases mentioned no case of persistent epiphyseal centers has been encountered in Schmorl's Institute. The "persistent epiphyses" therefore require some other explanation as they do not occur even in eunuchoidism in which a large number of epiphyses of the long bones may remain ununited. As an explanation there may be considered calcifications or bony gaps in the discs, spondylolitic growths of the borders and separated vertebral angles. The separation at the angles of the vertebrae have another explanation. It was formerly assumed that the triangular pieces of bone which were found in the lumbar vertebrae were of traumatic origin. This is not the case. They have the same origin as the cartilaginous nodules following prolapse of the vertebral discs. In spines with a predisposition and subjected to repeated shocks or pressure, the marginal tissues are dissociated from the cartilaginous disc and are dragged obliquely and anteriorly so that finally a triangular piece of bone is present at the anterior angle of the vertebral body. A knowledge of the slow development of those structures may be of value in settling lawsuits. In juvenile kyphosis the border epiphyses retain their normal structure. In this lesion there is a widening of the border contour of the lower anterior thoracic vertebrae as well as a marked flattening of the contours. These expansions are found only in the spine and are signs of juvenile kyphosis. The author can offer no support for the existence of the disease called "epiphyseal necrosis." In spondylitis deformans the bony contours show no changes.—*E. T. Leddy.*

MARDERSTEIG, KLAUS. Zur Frage der persistierenden Wirbelkörperapophysen. (Concerning persistent apophyses of the vertebral

column.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 441–449.

The author demonstrated among 720 patients 2 cases of persistent apophysis of the vertebral column in eunuchoidism in which there were also other accessory bone nuclei of the vertebrae. This fact makes it apparent that the term apophysis is more correct than the terms epiphysis or contour ridge. The author agrees with the view of Junghanns that the small triangular shadows which are found at the anterior corners of the vertebrae are due to bone formation or calcareous deposit or to displaced apophyses. Since he never observed the persistence of vertebral body apophyses distinct from the basal internal secretory disease, the author is unable to agree completely with the assumption of a traumatic origin—which is of importance in medicolegal work—until there is confirmation of this assumption by pathologic evidence gained at post-mortem examination.—*E. T. Leddy.*

Rathcke, L. Über Kalkablagerungen in den Zwischenwirbelscheiben. (Calcareous deposits in the intervertebral discs.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1932, *46*, 66–75.

Rathcke reports on the frequency of nuclear and annular calcareous deposits in the spine as observed in 200 cases. Nuclear deposits are much more common than annular. Up to the thirtieth year of life these calcifications are rare, but after that they seem to be of equal frequency in both sexes. In a table the statistical incidence is shown. No calcification was found in the cervical intervertebral discs. Nuclear and annular calcifications may occur in the same spine or in the same disc and often multiple annular or nuclear calcifications occur in the same spine. Multiple calcifications may lie one behind the other. The roentgenologic and clinical findings are compared and the point is brought out that the cases which show multiple annular calcifications encroaching on the soft parts or protruding from the edge of the vertebrae do not have symptoms. The size, form and location of the shadows have no relationship to the surfaces of the vertebral body. The annular deposits have no relationship to the osteophytic growths of spondylitis deformans. Annular and nuclear calcifications give homogeneous intense shadows which are easily distinguished from true osteophytes. These changes develop without clinical and physical signs. Their etiology is unknown. The author adopts the opinion of Schmorl that they are a degenerative process.—*E. T. Leddy.*

Chasin, Adib. Über Veränderungen in der Wirbelsäule nach Tetanus. (Changes in the spine after tetanus.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 427–441.

Chasin found 21 cases with more or less well-marked changes in the spine following tetanus. The roentgenologic characteristics are (1) flattening of one or more thoracic vertebrae as a result of which the height of the body may be decreased; (2) these changes are usually multiple; (3) there are zones of thickening in the upper and lower surfaces of the bodies; (4) focal thickening in the vertebral bodies is not seen; (5) the intervertebral spaces are normal; (6) no signs of an abscess were ever encountered, and (7) frequently there may be a kyphosis at the level of the spine of the vertebra which is most involved. The clinical and differential diagnosis from other lesions of the spine is discussed in detail.—*E. T. Leddy.*

Kühne, Konrad, and Gerstel, Gustav. Klinisch-röntgenologische und pathologisch-histologische Befunde bei einem Fall von allgemeiner Osteophytose (Osteoarthropathie hypertrophiante pneumique). (Clinical, roentgenological and pathologico-histological findings in a case of generalized osteophytosis (osteoarthropathie hypertrophiante pneumique).) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1932, *46*, 662–670.

The authors report the case of a boy sixteen years old who had lymphosarcoma with tumors in the lungs and very marked osseous changes in the long bones but none in the vertebral, pelvic, costal and cranial bones. There was a marked osteophytic growth in the volar side of the long bones of the fingers, a lesion not previously described. Microscopic examination of the bones after death confirmed the findings of C. Crump who first investigated osteophytic changes in the aged. The osteophytes in the juvenile bones showed no peculiarity.—*E. T. Leddy.*

Van Alstyne, Guy S., and Gowen, G. Howard. Osteitis tuberculosa multiplex cystica (Jüngling). *J. Bone & Joint Surg.*, Jan., 1933, *15*, 193–205.

In 1920, Jüngling reported his observations on a cystic condition of bone for which he claimed a tuberculous etiology and which he named at that time, "ostitis tuberculosa multiplex cystica." In 1911 he first noted the affection, involving the phalanges of the hands and the metacarpals and the phalanges of the feet and the metatarsals. Four later cases were observed by him and he noted the following facts: the onset of the disease is gradual; pain may be present early but is not severe; there is marked cystic degeneration of the bone which is readily demonstrable by roentgen examination; there is a tendency for the small cysts to fuse, forming larger cysts; there is a lack of involvement of the joints and periosteum; there may be lupoid involvement of the skin in the affected area; the histological picture shows epithelioid and lymphocytic cells, rarely giant cells, no caseation, and no tubercle bacilli; guinea pig inoculation is frequently negative for tuberculosis and, when positive, is slow, requiring several months; the von Pirquet test is usually negative; the course of the disease is slow with a definite tendency toward spontaneous improvement and even recovery.

The authors base their claim for a tuberculous origin of the case reported by them on: (1) microscopic tubercles in the cyst wall and in a regional lymph gland; (2) tubercle bacilli in the cyst content; (3) microscopic tubercles in the tissues of a guinea pig six weeks after inoculation; (4) tubercle bacilli in the inoculated guinea pig's lymph nodes; with (5) a positive von Pirquet test; (6) marked chronicity from the start, and (7) a very possible preëxisting pulmonary tuberculosis.

They also state that no report was found in the literature of this disease occurring in the larger long bones. Since the article was written however, Schwenkter has reported a case of this condition in a young child in whom the long bones were affected.

The lesions of their case are illustrated by roentgenograms of the fingers and toes, elbow and shoulder joint.

Previous to Jüngling's report, Fleischner had called attention to the frequent association of lupus pernio and Boeck's sarcoid with cystic changes in the bones analogous to the osteitis tuberculosa multiplex cystica of Jüngling, and attributed to both skin and bone lesions a common tuberculous origin.—*R. S. Bromer.*

CONE, SYDNEY M. Paget's osteitis deformans in relation to cardiovascular disease. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 190–192.

Cone believes that his clinical observations, coupled with the pathological findings in more than 900 autopsies, justifies the statement that osteitis deformans or Paget's disease is the result of chronic cardiovascular disease. It is the outcome of long-continued, intermittent high and low blood pressure, coupled with changes in organs of internal secretion so commonly accompanying cardiovascular disease. It is the result of the pathological, mechanical action of cardiovascular force long continued on tissues imprisoned by a dense encapsulated cortical bone and periosteum. This is encouraged by the internal secretions called on by bone changes already started by trauma, minute but constant. The bone changes are more severe where the pituitary, thyroid, or parathyroid glands are independently diseased. It is only after years of bone changes that static conditions produce the more characteristic curves and deformities by which the disease is clinically diagnosed.

Of 112 cases of cardiovascular disease seen at autopsy, all showed severe bone changes. The most marked cases were in 3 old men. The other 109 cases were individuals varying in age from seventeen to eighty years. Each had been the subject of cardiovascular disease for a long time. Disease of the heart musculature was common, valvular disease most usual and arteriosclerosis was invariable. Some of the older cases Cone states could not be distinguished from Paget's disease on study of the bone sections, except by the lack of excessive architectural changes and greater amount of cell changes. In looking through the description of Sir James Paget's cases, Cone found evidence of cardiovascular change in most of them. Also many of the cases described elsewhere in the literature were in persons with cardiovascular disease.

It appears to Cone that leontiasis ossea, described in the literature as an independent entity or as an early manifestation of Paget's osteitis deformans, points to a circulatory disturbance as the cause of the pathological disturbances in the bones.—*R. S. Bromer.*

COMPERE, EDWARD L. The rôle of the parathyroid glands in diseases associated with demineralization of the human skeleton.

J. Bone & Joint Surg., Jan., 1933, *15*, 142–150.

Hyperparathyroidism, usually associated with an adenomatous tumor of one or more of the parathyroid glands, has been established as the etiological factor in the production of generalized osteitis fibrosa cystica, a very chronic disease which progresses with pain, fractures, and disabling deformities, and may be fatal. It is a disease entity, Compere says, different from local osteitis fibrosa, osteitis deformans, osteogenesis imperfecta, osteomalacia, rickets, and ankylosing polyarthritis. The similarity in the roentgen appearance of some of the conditions in this group is well known, and the most experienced pathologist may at times find it difficult to differentiate between the gross or microscopic picture of bone affected by von Recklinghausen's disease and a section of bone from a case of Paget's disease. The clinical picture of several of the abnormal skeletal conditions mentioned may be similar to that of generalized osteitis fibrosa cystica (von Recklinghausen's disease). But while clinically, roentgenologically and pathologically similar, there is a difference in the biochemical manifestations of these diseases as demonstrated in studies of the mineral metabolism.

The mere recognition of osteoporosis of the human skeleton associated with hypotonia and decreased irritability of the muscles to electrical stimuli, with or without an elevation of the serum calcium, is too little evidence upon which to base a diagnosis of overfunction of the parathyroid glands. The presence of enlarged parathyroid glands, in the absence of a negative calcium balance, or at least a reduced calcium balance, is not enough evidence to justify their removal. Hyperplasia of the parathyroid glands may be a purely compensatory enlargement in response to a demand of the organism as a result of a deficiency of calcium absorption from the bowel. This has been demonstrated clinically in cases of deficiency diseases, such as osteomalacia and rickets. Since parathyroid tumors, benign hyperplasia, were produced experimentally on a deficiency diet and were found to recede when the deficiency was corrected, the hyperplasia in this condition was obviously compensatory.

In the reported cases of parathyroidectomy for ankylosing polyarthritis, a review of the description of the microscopic studies as well as of the photomicrographs published has failed to demonstrate a true adenoma of one or more of the parathyroid glands in the series. Although the serum calcium may be slightly above normal, the inorganic phosphates of the plasma are normal, and the calcium balance is positive. Demineralization of the skeleton in polyarthritis may be accounted for as atrophy of disuse. All this is evidence that ankylosing polyarthritis is probably not caused by hyperparathyroidism.

There is no good evidence that Paget's disease is caused by hyperparathyroidism. In this condition the calcium and inorganic phosphate content of the blood are normal; the calcium balance in the chronic phase of the disease is markedly positive; the output of urinary calcium is greatly decreased; and the parathyroid glands are usually found to be entirely normal in size and in microscopic structure.

Parathyroidectomy in cases of ankylosing polyarthritis or of Paget's disease is not a justifiable procedure unless there is more adequate evidence of parathyroid gland pathological changes than has been presented in reports of cases in the literature.—*R. S. Bromer.*

Ballin, Max. Parathyroidism in reference to orthopaedic surgery. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 120–134.

Ballin begins his paper by stating that parathyroidism due to hyperplastic or adenomatous conditions of the parathyroid glands has become a recognized entity. He uses the shorter word parathyroidism instead of the longer word hyperparathyroidism. Its main symptoms are an elevated serum calcium with some decrease in the serum phosphorus, increased calcium and phosphorus in urine and feces, larger than the intake, and therefore a negative calcium and phosphorus balance. It is important to understand that this surplus of calcium in serum and excretions under the influence of increased parathyroid function is taken from the skeleton; therefore decalcification of the bones, osteoporosis and late regressive changes, osteitis fibrosa cystica, bone cysts, osteoclastic processes, giant cell tumors, deformities, and pathological fractures of the softened bones are sequelae of increased parathyroid function—that is, parathyroidism. Besides the skeletal changes, gastrointestinal and urinary symptoms, metastatic calcium deposits, and muscular hypotonia occur.

Repeated injections or overdoses of parathormone will produce decalcification of the skeleton, typical osteitis fibrosa cystica with osteoclastic processes and giant cell formation, hypercalcinuria, intestinal upsets, great muscular weakness, and, in poisonous doses, death from these symptoms. These same conditions are seen in human beings suffering from parathyroidism.

Ballin has collected 100 cases in the literature, together with his own, in whom parathyroidectomy was performed and in all except a few, suffering surgical mortality, good results were obtained. Three of these cases died from postoperative tetany and in a few no parathyroids were found. He advocates leaving one or possibly two functioning parathyroids.

The following types are recognized: (1) the vertebral form, mainly expressed by kyphosis and compressed vertebrae, usually slow in progress; (2) the infantile type, usually more rapid; (3) the arthritic type; (4) the Paget type; (5) types where muscular hypotonia or gastrointestinal symptoms are more prominent than the skeletal.

People of all ages are subject to the disease. In the first type, the vertebral, Ballin places the cases of wedge-shaped vertebrae causing kyphosis, sometimes called disturbances of the nucleus pulposus, cases that resemble metastatic carcinoma, and patients who in old age become shorter and bend over due to the so-called senile spondylarthritis or senile kyphosis.

In the second class, the infantile, he groups the usual type of osteitis fibrosa cystica as seen in the young, cases which from the roentgenograms reproduced, resemble osteogenesis imperfecta, multiple enchondromata, and even the cases of so-called slipping epiphysis. In the latter instance he has operated upon 4 cases, claiming beneficial results after parathyroidectomy, recommending that the operation be performed early. Even though he calls this group infantile, he classes the case reported by Quick and Hunsberger, aged eighteen, under this heading.

In the third, the arthritic form, he states that parathyroidism has a distinctive place as to origin of the disease.

He believes that the results of parathyroidectomy in his cases of Paget's disease confirm the opinion that osteitis fibrosa cystica and Pagets' disease are identical and can be controlled by parathyroidectomy.

In the fifth type, he states, a few cases of parathyroidism will express themselves mainly in gastrointestinal symptoms while in others muscular weakness will be outstanding. He advises four methods in determining the latter: (*a*) the determination of the milliamperes needed to provoke the muscular contraction (Oppel); (*b*) chronaxia; (*c*) the use of the moving picture to show the slow and weak action of muscles (Rowntree); (*d*) the electrocardiogram to show weakness of the heart muscle.

Using the ideas of Moreau as an hypothesis he classes sclerosing diseases of bone as melorheostosis (Léri), leontiasis ossea, Sicard's disease, and the eburnating osteitis of Putti as likely parathyroid disturbances. He also mentions marble bones, osteopoikilosis, hypophyseal dysostosis or Schüller-Christian's syndrome, calcification of the nucleus pulposus and Kümmell's disease as probable members of the group.

In his conclusion, he mentions that besides the parathyroid, the thyroid, Cushing's syndrome in certain adenomata of the anterior lobe of the pituitary gland, and other rarer endocrine disorders may show skeletal disturbances, but probably a parathyroid factor is present in all of these types.

As to treatment, a trial with the well-known therapy for rickets and osteomalacia (sunlight ultraviolet rays, irradiated cod-liver oil, and calcium preparations) is worth while; transitory forms from rickets, Ballin states, with only compensatory hyperplasia of the parathyroids to real parathyroidism, also mild types of the latter, may yield to such treatment. Rapidly progressive cases of parathyroidism and exacerbations after temporary remissions should be operated upon before permanent deformities of the skeleton or serious damage, especially to the kidneys, supervene. —*R. S. Bromer.*

Bauer, Walter. Hyperparathyroidism: A distinct disease entity. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 135–141.

Bauer believes that there are not sufficient data at hand to prove that arthritis and Paget's disease are due to an increased secretion of the parathyroid hormone. Hyperparathyroidism or generalized osteitis fibrosa cystica is a clear cut, distinct disease entity caused by an increased secretion of the parathyroid hormone. All cases thus far reported have been due to a

parathyroid adenoma. The entire skeleton is affected. Arthritis and Paget's disease are never generalized skeletal diseases. This fact argues against their being of parathyroid origin.

The alterations in the calcium and phosphorus metabolism in hyperparathyroidism are: (1) an elevated serum calcium; (2) a decreased serum phosphorus; (3) an increased calcium excretion; (4) an increased phosphorus excretion.

These alterations may be accompanied by some or all of the following clinical symptoms and signs: polydipsia, polyuria, weakness and loss of strength, constipation, loss of appetite and loss of weight, indefinite muscle and joint aches and pains, bone tenderness, frequent fractures, often following slight trauma, decreased excitability of the nerves, skeletal shortening, kyphosis, bone tumors, frequently diagnosed as epulis of the jaw or giant cell tumor in other bones, kidney or ureteral stones, and anemia with leucopenia. The roentgen findings are characteristic; such as, generalized decalcification, bone tumors, multiple bone cysts, fish-type vertebral bodies, etc.

He does not believe that any patient should be subjected to a parathyroidectomy until sufficient evidence has been gathered from the history, physical examination, roentgen examination and metabolism studies to leave no doubt as to the correctness of the diagnosis of hyperparathyroidism. Serum calcium and phosphorus determinations should be made as well as serum phosphatase and total calcium and phosphorus metabolic studies.

Previous cases reported in whom parathyroidectomy was performed for arthritis of the ankylosing type and for spondylitis deformans (Strümpell-Marie type) were operated upon and no studies were presented in the reports to show previous alterations in the calcium and phosphorus metabolism, nor were sufficient data pertaining to the history, physical examination and roentgen examinations presented to enable one to make a diagnosis of increased parathyroid function. The mere elevation of the serum calcium which is occasionally found in arthritic cases is not sufficient evidence on which to base a diagnosis. As a result of studies made by himself and others, Bauer can state that no changes in the serum calcium or serum phosphorus were found in arthritic cases of a degree sufficient to enable one to make a diagnosis of hyperparathyroidism. The alterations in the calcium and phosphorus metabolism were hardly any more marked than one obtains in a study of a large series of normal individuals observed on the same regimen. Improvement reported in some cases following parathyroidectomy may have been due to anesthesia, rest in bed, or a natural remission of the arthritic process as is sometimes observed. In 7 cases observed at the Massachusetts General Hospital, all showing sufficient evidence to make a diagnosis of hyperparathyroidism, none showed any coincident arthritis.

Bauer cannot agree with the statement made that Paget's disease is also caused by hyperparathyroidism. Paget's disease occurs in older people, usually males, and is regularly associated with marked arteriosclerosis, whereas hyperparathyroidism is met with in all age groups, more commonly in females, and arteriosclerosis is not a common finding. Malignant bone tumors develop in a fair number of cases of Paget's disease, but rarely, if at all, have they been observed in hyperparathyroidism. Renal calculi are rarely found in Paget's disease but are very often found in hyperparathyroidism. The bones in Paget's disease are soft, often bowed, and a thickened cortex is demonstrable on both roentgen and macroscopic examination. In hyperparathyroidism, roentgen examination shows bones with thinned cortices, bone cysts, and the brown tumors described by von Recklinghausen.

A high serum phosphatase is present in both diseases, but is more marked in Paget's disease. This elevation may occur in other conditions than Paget's disease. Patients with the latter condition showed no elevation of the serum calcium or lowering of the serum phosphorus. The patients studied by Bauer and others were cases of Paget's representing various ages, and also the early and late stages of the disease. Schmorl concluded that Paget's disease was not due to hyperparathyroidism because of his inability to find bone tumors. He also found no enlargement of the parathyroids in Paget's disease under normal conditions. In discussing its etiology he presents certain evidence that the observed pathology might best be explained on a vascular basis, and also suggests that stress and strain may well play a rôle in bringing about the bone changes. In support of this theory he shows that the bones subjected to the most stress and strain are most frequently involved.

Mere clinical improvement in cases following parathyroidectomy in Paget's disease should not be regarded as proof that hyperparathyroidism is a cause of the condition, inasmuch as in the natural course of the disease there may be periods when the patient may complain of very few symptoms.—*R. S. Bromer.*

Funsten, Robert V. Certain arthritic disturbances associated with parathyroidism. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 112–119.

A survey of arthritic cases was made in order to isolate those which might fit into the parathyroid group. Ninety-five cases of arthritis, chiefly of the ankylosing type, were examined. Twenty-six of these showed symptoms suggestive of parathyroidism. The development of arthritis in the presence of parathyroid disturbance is a common occurrence, and is frequently responsible for the first symptoms.

The history of the patients is that of prolonged pain, weakness, and stiffness in the joints, particularly the spine, and the pain is not relieved by orthopedic methods for any considerable time. The pain may be paroxysmal, especially in the spine and abdomen. Roentgen examinations show characteristic demineralization of the spine, long bones and skull. The diagnosis may be substantiated by means of repeated blood and urine calcium determinations and chronaxia. Following parathyroidectomy there is almost immediate relief of pain and a feeling of relaxation in the joints. In the milder cases, when it is not possible to make an absolute diagnosis and in poor surgical risks, treatment by means of cod-liver oil concentrate and calcium gluconate accompanied by conservative orthopedic treatment may lead to improvement and arrest of the disease, at least temporarily.

Parathyroidectomy was performed in 14 of the 26 cases. Only one of the cases operated upon failed to show improvement. This young woman had cervical arthritis with radiculitis. Nine cases showed marked improvement. Within a day or two following operation, the sensation of stiffness in the joints began to disappear and there was less pain and more ease of motion. The cases were classified as markedly improved only when entirely free from pain and when the roentgenograms showed an increased density in the bones. Four cases were moderately improved. The shortest postoperative observation was four months; the longest period of observation was eighteen months. The operations for the removal of the parathyroids, all of which were performed by Dr. Ballin, have not been accompanied by tetany or shock, and can be considered sufficiently harmless to justify the procedure in even the milder cases.—*R. S. Bromer.*

Nachlas, I. William. Considerations on the use of parathyroidectomy for arthritis. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 151–152.

Parathyroidectomy has been performed for the cure of arthritis and favorable results have been reported in some patients. Under the heading of arthritis a heterogeneous group of clinical syndromes is included. One would, says Nachlas, hardly give credence to any proposed single cure for all classes of dermatitis, though the point of involvement is the same in all cases. In the same way, one can hardly accept any one method of cure for the numerous ailments which happen to have as their common interest only a predilection for synovial membranes.

The use of parathyroidectomy as a therapeutic measure in arthritis predicates disturbances of lime-salt metabolism and is based on the fact that the parathyroid secretion mobilizes these salts. While the evidence is quite convincing that calcium-phosphorus deposits in bone are affected by these endocrine glands, one can hardly accept, without some doubt, the statement that arthritis is a disease of mineral-salt metabolism. Nachlas has studied the serum calcium in 37 cases and has found no change from the normal. In the same cases, the blood phosphorus was studied with the idea of differentiating the hypertrophic from the infectious arthritic, but no uniform variation from the normal reading was obtained. The only deduction that could be made was that the phosphorus level was lower in the osteoarthritic than in the infectious arthritic. He believes from the data obtained, that no one has the right to assume that arthritis is the result of calcium-phosphorus dyscrasia.

Most of the parathyroid therapy for bone conditions is based on the assumption that the hormone removes lime salts from the osseous tissue. Recent investigations have shown that this is a matter of dosage. The effect of the parathormone in animals varies with the calcium-phosphorus intake in a very decided man-

ner. The diet is linked with the whole problem.

The question of what becomes of the lime salts liberated from the skeletal system has not been answered. Laboratory experiments have shown that the liberated calcium phosphate may be deposited in other areas, such as the blood vessels and the kidneys. The importance of accurate knowledge of the production of such calcifications need hardly be stressed, since obviously the cure may prove to be much more serious than the disease. Nachlas thinks that it is desirable at present to entrust the proposed thyroidectomy for arthritis to capable investigators rather than to accept it as a determined curative method for arthritis.—*R. S. Bromer.*

Buschbeck, Herbert. Beitrag zur Kenntnis röntgenologisch Sichtbarer (bisher als Enostosen beschreibener) Gebilde in der Femurspongiosa. (Contribution to our knowledge of the roentgen visibility of shadows in the femoral spongiosa (hitherto termed enostoses).) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1932, *46*, 53–66.

The author reports 11 cases diagnosed histologically as calcified enchondromas, on the basis of which he attempts to represent their peculiar roentgen appearance. In the light of his experience he reviews critically the cases published by Salinger and Luber.—*E. T. Leddy.*

Faber, Alexander. Kippstellung des Talus. (Dislocation of the astragalus.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1932, *46*, 457–462.

By roentgenologic examination of the ankle joint in forced supination and pronation and moderate dorsoflexion of the foot in the dorsoplantar roentgen position, there has been recognized for a long time a type of distortion of the ankle joint which may be attributed to rupture or weakness of the lateral ligaments, giving rise to a deviation of the astragalus within the malleolar fork. In this type of roentgenogram of the astragalus there is a deviation toward the side of the injury to the ligaments. It is necessary to examine both feet for this deviation as other non-traumatic causes such as defective or weakened ligaments may give rise to a similar malposition of the astragalus. It is often impossible to decide whether this lateral dislocation is of traumatic origin or is due to primary defectiveness. From the point of view of prognosis and therapy of recent distortions, it seems better to use the method of examination described by the author rather than to rely on the clinical history or the usual roentgen examination to exclude fracture. The method detailed is important in insurance cases because it allows an objective determination of the status of old dislocations independent of the subjective symptoms of the patient.—*E. T. Leddy.*

Robertson, Robert C., and Bogart, Franklin B. Fracture of the capitellum and trochlea, combined with fracture of the external humeral condyle. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 206–213.

The authors report 3 cases of vertical fracture of the capitellum and trochlea en masse, combined with oblique fracture of the external condyle, the displacement of the fragment being usually upward and forward. They state the fracture may be produced by falls on the hand with the elbow extended. Another author, whom they quote, describes two mechanisms: the one such as mentioned above, the force being transmitted through the long axis of the radius and ulna to the capitellum and the trochlea; the second being a blow on the upper part of the dorsum of the partially flexed forearm, transmitting the force through the articular end of the ulna and the head of the radius to the capitellum and the trochlea. In Robertson and Bogart's cases, 2 of the 3 showed bony union in good position, with good functional results following closed reduction. Other authors have advocated excision of the fragment as the treatment of choice. The article is well illustrated with roentgenograms of the fractures before and after reduction.—*R. S. Bromer.*

Peabody, Charles W., and Muro, Felipe. Congenital metatarsus varus. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 171–189.

This paper is a summary of the pathological character and, in most instances, of the response to treatment of 14 cases of a congenital foot deformity, apparently to be recognized as a definite clinical entity, distinct from talipes equinovarus, yet almost devoid of consideration in text and literature in the English language. The European Continental literature of the last twenty-five years was found to contain numerous references and case reports of this condition in which Peabody found some of

distinct value in the study and treatment of the deformity. The general type of deformity may be properly divided, he says, into metatarsus adductus and metarsus varus.

The differentiation from the common type of club-foot is made easier by the following points: (1) equinus is never present in this deformity as in common club-foot; (2) the sole of the foot is always flat, or nearly so; (3) in spite of the impression of a varus foot, there is seen to be no ankle varus or supination at the sub-astragaloid joint, but on the contrary, valgus or pronation, with marked inward rotation and luxation of the head of the astragalus, the scaphoid and mesial cuneiform being displaced laterally.

The major element of the deformity involves the forefoot, beginning with the cuneiform bones, which are rotated in a varus direction and are abnormally overlapping, so that the upright perpendicular might pass through all the second, third and fourth to a marked degree, are incurved in their diaphyses and to some degree are dorsally convex. The first metatarsal is usually straight, but articulates at its base with the mesial aspect of the inner cuneiform and makes a marked varus angle with the mesial aspect of the foot back of this point, the greatest concavity being between the scaphoid and the metatarsal. The cuneiform tends toward a lateral position with respect to the scaphoid. In the younger cases, no incurving of the metatarsal is frequently shown, but a distinct adduction deviation of the metatarsus on the tarsus, but with the same abducted or valgus position of the calcaneum and inward rotation and depression of the talus. This group presents the possibility of a separate classification of "metatarsus adductus." Stresses resultant from walking on this type of foot would be very likely to bring about the incurving and luxations noted in the older cases.

The deformity was not noted in infancy in Peabody's cases and also was not noted usually until walking began and became more apparent as time went on. Functionally, the effect in the smaller children was of tripping and stumbling. In older children the outer border of the foot became callous and painful, the shoes became out of shape and were quickly worn through, with clumsiness persisting in the gait.

Etiologically, the theories commonly put forward have been those in the past frequently ascribed to talipes equinovarus, namely, amniotic compression. Bankhead, however, considered that as a result of his operative findings in his cases that the internal cuneiform bone was absent and, by this failure of development was responsible for the deformity. Peabody's cases observed after the normal age of ossification of this bone have shown its normal development roentgenologically. In one case a distinct anatomical variation in the insertion of the tendon of the tibialis anticus was found, it being inserted with fan-like multiple fibers into the plantar fascia or the mesial portion of the transverse metacarpal ligament instead of the mesial aspect of the cuneiform as in normal cases.

In the cases of metatarsus adductus, satisfactory results were obtained by molding in plaster only. In metatarsus varus, only mild cases respond to this technique and open operation is necessary in most cases.—*R. S. Bromer.*

FERGUSON, ALBERT B. Short metatarsal bones and their relation to poliomyelitis. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 98–100.

Ferguson's article deals with those cases in which one or more of the metatarsal bones from the second to the fourth is short relative to the others with no evidence of fracture, malformation or disease. Such cases are usually referred to as congenital malformations, but this is rarely the cause of the shortening.

Forty-two cases of simple shortening of the second, third, and fourth metatarsal bones were studied. Twenty-seven of the 42 patients were known to have had poliomyelitis, 7 probably had it, 5 may have had it and 3 had no history or muscular weakness suggesting it.

Ferguson thinks the deformity is the sequel of poliomyelitis in most cases and its presence is strong evidence that the patient has had the disease unless congenital club-foot is present. The deformity tends to occur in those cases in which there has been extensive paralysis of a leg early in life (before the age of four), with involvement of the anterior tibial muscle, but the deformity does not appear until early adolescence, when the epiphysis unites prematurely. In no case of the series did the deformity appear to be a congenital malformation.—*R. S. Bromer.*

CLARK, DWIGHT F., and QUINT, H. A. Dislocation of a single cuneiform bone. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 237–239.

The authors after reviewing the literature found scarcely a half dozen references in which mention is made of a dislocation of the anterior tarsal bones of the foot and none could be found of displacement of a single cuneiform bone. Roentgenograms of their case of dislocation of the middle cuneiform bone of the right foot are shown, taken immediately after the injury, after ten days following an unsuccessful attempt at reduction, and after the fifth week following osteotomy of the middle cuneiform.

The patient's right foot was doubled under the brake pedal when her automobile skidded and hit a tree. She felt no particular pain at the time of injury.

The case is reported by Clark and Quint because of its rarity and because of their opinion that such cases may occur more often than is supposed. It is probable that imperfectly taken roentgenograms, especially those in the lateral position with a certain degree of rotation, may fail to bring out such a displacement even when well interpreted. Furthermore, inexperience in interpretation in either good or bad roentgenograms may be responsible for the neglect of recognition and proper treatment of this disabling injury. The laying down of fibrous tissue in the normal bed of the displaced bone soon makes mechanical reduction impossible. Reduction may not even be accomplished when attempted early. In the few instances on record of displacement of the anterior tarsal bones, both untreated and treated cases show uniformly poor functional and anatomical results. —*R. S. Bromer.*

BUCHMAN, JOSEPH. Osteochondritis of the internal cuneiform. *J. Bone & Joint Surg.*, Jan., 1933, *15*, 225–232.

Two cases presenting three instances of a hitherto undescribed and apparently rare focus of osteochondritic derangement of the internal cuneiform, associated with a similar involvement of the tarsal scaphoid, are reported. The subsequent history of the first patient revealed a benign course and a reconstitution of the affected bones to a practically normal, though somewhat deformed and undersized state.

The roentgenographic characteristics of the condition were irregularity of shape with lessening of the longitudinal diameter of the affected bone, with scattered areas of condensation and rarefaction. The scaphoid which was also affected showed several centers or nuclei of ossification. Underdevelopment was also a constant finding.

Buchman enumerates the various locations in the bony skeleton where this condition is found, discusses the normal ossification of the cuneiform bones and mentions the possibility that the cause of the condition is an imbalance of stress and strain upon a physiologically weakened area. This imbalance may be due to an increased stress and strain, resulting from an abnormal weight or excessive activity, or it may be due to a diminished resistance incidental to rapid growth.—*R. S. Bromer.*

JENKINS, HILGER P., and DELANEY, P. ARTHUR. Benign angiomatous tumors of skeletal muscles. *Surg., Gynec. & Obst.*, Oct., 1932, *55*, 464–480.

The authors report a case of benign angiomatous tumor of the gluteus maximus muscle of the arterial type. They collected and analyzed the reports of 256 cases from the literature. In regard to age incidence, 79 per cent occurred before the age of twenty and 94 per cent before the age of thirty. The etiology is obscure although the congenital factor seems important, and a history of trauma was obtained in 17 per cent of the cases. The symptoms are pain, tenderness, functional impairment, associated with a slowly developing tumor mass. This occurs most frequently in the extremities, especially the lower and particularly the thighs. The quadriceps femoris was the most frequently involved muscle. Treatment is surgical excision with a good prognosis as to life and function, impairment of function being observed in only 5 per cent of the cases and recurrences in only 6 per cent.

Diagnosis was made preoperatively in only 8.2 per cent of the 256 cases. The accuracy of the diagnosis was aided by aspiration of blood from the tumor and by the presence of phleboliths as demonstrated roentgenologically. Differentiation must be made from lipoma, sarcoma and cold abscess, although in the above cases there were 23 different diagnoses made preoperatively. The roentgenologic findings are a soft tissue tumor mass frequently containing phleboliths or other evidence of calcification, not attached to the bone but occasionally producing a pressure defect in adjacent bone or a periosteal reaction.—*J. H. Vastine.*

Straus, Francis Howe. Marching fractures of metatarsal bones. *Surg., Gynec. & Obst.*, March, 1932, *54*, 581–584.

Insidious fractures of metatarsal bones may occur after exhaustion of the normal muscle and tendon support to the foot. Such fractures occur without obvious trauma, and without sufficient immediate pain to notify the patient of the injury. Weeks later the developing callus becomes painful and calls attention to the lesion, but by this time the swelling is apt to be considered a neoplasm unless the observer is familiar with the picture of a marching fracture. The incidence of these fractures is 54.5 per cent in the second metatarsal, 36.8 per cent in the third, and 2.5 per cent in the fourth. When a case of apparent neoplasm involving the periosteum of the second, third or fourth metatarsal bones presents itself, the roentgenologist should be most hesitant to rule out march foot. The negative evidence of fracture is misleading as is also the erosion of cortex under the new bone growth.

The author reports a case of marching fracture which was operated upon with a preoperative diagnosis of sarcoma. Examination of the excised metatarsal showed a concealed fracture and histological examination of the callus showed no evidence of neoplasm or bacterial inflammation. Thiele reported 17 cases from one battalion in $3\frac{1}{2}$ months. Various theories have been offered as to the cause of these fractures, the simple, mechanical explanations of Kirschner being quite satisfactory, that is, exhaustion of muscle and tendon protection.—*J. H. Vastine.*

Kraft, Ernst, and Kato, Katsuji. Röntgenbefunde bei Bleivergiftung in Kindesalter. (Roentgen findings in lead poisoning in children.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1932, *46*, 249–256.

In 3 cases of lead poisoning in young children dense band-like zones were found in the metaphyses of the bones, which are important diagnostic signs. These shadows are of a lamellar type, unlike those present in phosphorus poisoning. Experiments on animals confirmed the roentgen findings.—*E. T. Leddy.*

ROENTGEN AND RADIUM THERAPY

Wintz, H. Strittige Fragen bei der temporären Strahlenamenorrhoe. (Disputed questions in regard to temporary amenorrhea from irradiation.) *Strahlentherapie*, 1932, *45*, 653–656.

The question of possible injury to mother or child from temporary sterilization by roentgen irradiation was thoroughly considered by the Bavarian Obstetrical and Gynecological Society. They found that there is no injury to the mother. The possibility of injury to the child depends on whether early or late fertilization takes place. Early fertilization is that which takes place in the first month or two after the sterilizing dose is given before amenorrhea has begun, late fertilization that which takes place after the roentgen amenorrhea is terminated. They found that injury of the child might be possible in early fertilization but not in late fertilization. Among the 500 children who have been born of mothers temporarily sterilized none have shown phenotypic injuries.

A recent publication of the German Society for Research in Heredity, however, gives a warning against the use of temporary sterilization as they say the genes may be so injured that late results may occur after generations. Wintz thinks that this statement is unfounded and that no such danger exists. Müller showed that mutations can be produced by irradiation in *Drosophila melanogaster*, but Wintz holds that these findings cannot be applied to man. Experiments have been carried out on mammals through six generations without showing any injury. He thinks the Society for Research in Heredity should revise their opinion or bring forth definite scientific proof of it, for if it is true it would mean not only that temporary sterilization must be given up but also that all diagnostic irradiation of the male and female pelvis is contraindicated.—*Audrey G. Morgan.*

Luxenburger, Hans. Temporäre Strahlenamenorrhoe und menschliche Erbforschung. (Temporary sterilization by irradiation and research in human heredity.) *Strahlentherapie*, 1932, *45*, 679–690.

It has been absolutely proved that mutations can be brought about in plants and animals by roentgen irradiation. The objection has been made that the results in *Drosophila* cannot be applied to man but A. Bluhm has performed experimentations on mice which show that mutations can be brought about by alcohol and it seems highly probable that mutations can also be brought about in man and other mammals

by roentgen irradiation. Of course this has not actually been proved by experiment for man as yet for that would require several generations. But man has a greater number of pathological hereditary characteristics than any other species of animals. It is highly improbable that they all existed in the genes of the original ancestor of the race and so they must have been introduced by mutations brought about by external influences. The burden of proof rests on those who hold that such mutations cannot be brought about and that the results of animal research cannot be applied to man, as they are using a method of treatment that is dangerous to the race if such mutations are possible.

To settle the question absolutely several generations of the descendants of women who have been irradiated must be studied and for this purpose a most careful investigation of the family history is necessary in order to exclude pathological anlagen that may have existed before the irradiation.

The author thinks a warning should be given not only against temporary sterilization but also against repeated diagnostic irradiations of the pelvic organs, as such irradiations are rarely necessary to the life of the individual and the advantages do not outweigh the danger to the race.—*Audrey G. Morgan.*

Maurer, E. Untersuchungen an Kindern strahlenbehandelter Mütter. (Examinations of children whose mothers have been irradiated.) *Strahlentherapie*, 1932, *45*, 691–699.

The question of whether children are really injured by roentgen irradiation of the mother during pregnancy is a very difficult one to answer and the question of whether such injuries, if they exist, can be transmitted to the offspring is still more so.

Flaskamp reported 214 children whose mothers had been irradiated during pregnancy and since then enough new cases have been reported to bring the number up to 229. There were pathological findings in 53 of these cases, or almost 25 per cent. But in a number of cases that the author has had occasion to examine similar pathological conditions existed in elder brothers or sisters who had been born before the irradiation. That is to say, many of these pathological conditions were congenital and familial and not caused by the irradiation.

The only way to settle the question definitely is to collect accurate data on the children and the families and to record the dosage and time of irradiation. An outline of the necessary information to be obtained is given. All of this material should be sent to a central institute and the children reexamined about every three years. In this way data could be collected that would settle the question.—*Audrey G. Morgan.*

Nürnberger, L. Die Entschilessung der Deutschen Gesellschaft für Vererbungswissenschaft zur Frage der Spatschädigung durch Röntgenstrahlen und ihre Folgen für die Strahlentherapie. (The resolution of the German Society for Research in Heredity in regard to late injury by roentgen rays and its consequences for radiotherapy.) *Strahlentherapie*, 1932, *45*, 700–710.

The author discusses a resolution adopted by the German Society for Research in Heredity and the German Society for Race Hygiene in September, 1931, in which they point out the danger of injury to the race by changes brought about in the germ plasm by roentgen irradiation and say that this danger is proved by exact scientific experiments. The author takes exception to this statement and says that it is by no means proved. He says further that the adoption of the resolution involves serious consequences for roentgenologists. Before its adoption if a mother who had been irradiated gave birth to a defective child she had no ground for action against the roentgenologist and the judge would have been obliged to dismiss such a suit for want of evidence. But now since the adoption of such a resolution by two such well-known and powerful associations it can be brought forward as evidence that there is danger and that the roentgenologist must have known that such danger existed. And even if the child is apparently normal such a fear of late consequences may be awakened in the parents' minds that their lives are embittered.

The author believes the societies were wrong in adopting such a resolution not based on definite scientific evidence, and that if there had been definite scientific evidence of late injury of the germ plasm by irradiation they should have condemned not only temporary sterilization but any irradiation of the pelvic organs even for diagnostic purposes as Wintz claims that small doses of irradiation are particularly apt to cause mutations.—*Audrey G. Morgan.*

DYROFF, RUDOLF. Vergleichende Ovarhistologie in Beziehung zur Keimschädigungsfrage durch Röntgenstrahlen. (Comparative histology of the ovaries in relation to the question of injury of germ plasm by roentgen rays.) *Strahlentherapie*, 1932, *45*, 711–733.

A difference of opinion has arisen between the gynecologists and students of heredity in regard to the possibility of causing injurious mutations in human beings by roentgen irradiations. The claims of the eugenists are based on experiments on *Drosophila*. In an effort to show that these findings are not applicable to man the author discusses the comparative histology of the ovary in diptera and mammals. It is known that irradiation has a more intense action on cells that are active metabolically than on those that are in a resting stage. The maturing ova of the human ovary are engaged in active metabolism while the primordial ova are in a quiescent stage and are therefore resistant to irradiation. Therefore in early fertilization soon after irradiation there might be injury of the offspring. This, however, can be prevented by refraining from coitus for the first few months. But the primordial ova which are fertilized later after the end of the roentgen amenorrhea have not been injured and therefore no injury to the child can result in late fertilization. But in the ovary of the diptera there are no resting ova corresponding to the primordial ova in mammals and therefore the experiments on *Drosophila* have no bearing on the question in man.

Spermatozoa also show a relatively high metabolism and so experiments on male mammals are not conclusive. The only experiments that would be really conclusive would be those on female mammals. In the meantime the preponderance of evidence is that there is no danger of harmful mutations in late fertilization.—*Audrey G. Morgan.*

NEEFF, TH. C. Das Dosierungsproblem bei der temporären Strahlensterilisierung. (The problems of dosage in temporary sterilization by irradiation.) *Strahlentherapie*, 1932, *45*, 734–739.

It has been questioned whether dosage for the ovary can be made accurate enough to ensure only temporary sterilization. It is hard to determine the exact position of the ovary, and the different tissues of the body are not homogeneous. The lack of homogeneity, however, can be compensated for and a good deep dosage can be obtained by using as hard rays as possible with a tension of not less than 180 kv. and a filter of 0.5 mm. copper. With this irradiation the possible error from inhomogeneity is not more than 2 per cent. In order to measure the dose applied to the ovary accurately it is best to place a dosimeter in the posterior vault of the vagina and to irradiate from two fields, back and front. Instead of turning the patient over, which would result in some displacement of the ovary with reference to the dosimeter, the irradiation should be given from two tubes simultaneously. A table arranged for this purpose is described and illustrated. When this method is used with large fields, about 20×20 cm. and a distance of about 50 cm. the dose is quite uniformly distributed for a zone of 5–6 cm. in the deep tissues.

Counting the sources of error from lack of homogeneity, vaginal measurement and possible defects in the instrument, the maximum error need not be more than ±5 per cent. The average ovarian dose for temporary sterilization is about 230 r and that for permanent sterilization about 280 r, so there need be no fear of exceeding the temporary sterilizing dose. By the use of Kadisch tables it is possible even to graduate the dose finely enough for different age levels.—*Audrey G. Morgan.*

ALBRECHT, HANS. Klinische Erfahrungen mit der temporären Röntgenmenolyse. (Clinical experience with temporary roentgen amenorrhea.) *Strahlentherapie*, 1932, *45*, 740–746.

The author discusses his experience with temporary roentgen sterilization in polymenorrhea from various causes, gonorrheal and tuberculous affections of the adnexa, endometrioid tumors of the ovary and peritoneum, diseases of other organs, as, for example, pyelitis, which grow worse during the menses, and in psychic and nervous disturbances caused by the sexual cycle. The results were excellent. He gave a dose of 20–30 per cent of an erythema dose, generally at one sitting. The patients usually had one or two slight periods after the irradiation, then a period of amenorrhea for from several months to a year and then normal menstruation was reëstablished in all the younger women. The amenorrhea sometimes persists in women in the preclimacteric period. The signs of loss of function were not serious and dis-

appeared after menstruation was reëstablished.

The objection has been made to the method that it endangers future offspring. The author does not believe this is true of late fertilization but even if it is it would not affect the value of the treatment for preclimacteric cases. In view of the objections that have been raised to the method, however, as a result of the resolution of the Societies of Eugenics and Heredity he advises gynecologists to limit its use to women past the child-bearing age or among younger women to those cases in which there is a vital indication and these patients should be warned against having children.—*Audrey G. Morgan.*

V. Krenninger-Guggenberger, J. Der Oestrus das Zeichen für den Ovulationsbeginn nach temporärer Röntgensterilisierung im Tierversuch. (The estrus as a sign of the beginning of ovulation after temporary roentgen sterilization.) *Strahlentherapie*, 1932, *45*, 747–750.

In studying the question of late injury after roentgen sterilization, the author thinks the estrus in mice should be considered analogous to menstruation in humans. Until a few years ago, temporary infertility in animals after roentgen irradiation was considered the analogue of amenorrhea in humans, but it cannot be assumed that any infertility in white mice is equivalent to a cessation of ovulation such as occurs in amenorrhea. It is therefore of great importance to observe the estrual cycle in mice in order to sort out accurately the cases of early fertilization or fertilization of ova that have been irradiated.—*Audrey G. Morgan.*

Borak, J. Über die Möglichkeit und Wahrscheinlichkeit von Keimschädigungen nach Ovarialbestrahlungen. (On the possibility and probability of injury to the germ cell after irradiation of the ovaries.) *Strahlentherapie*, 1932, *45*, 751–758.

The author holds that even if roentgen rays are capable of producing mutations in the immature germ cells of *Drosophila* such as those that have been demonstrated for the mature cells it would be of very little consequence for man. In order for inherited injuries to become manifest there must be a large number of offspring and inbreeding must take place. Dr. Piller, a noted social hygienist, has undertaken to calculate the probability of inherited injury after roentgen amenorrhea. Taking into consideration the small number of offspring in man and the lack of inbreeding, he comes to the conclusion that if 2000 women were temporarily sterilized in Germany per year, among a million children in the second generation less than 0.2 per cent and in the third generation less than 0.5 per cent would deviate from normal on account of the irradiation. In the second generation, therefore, the probability of inherited injury would be 1:5,000,000. Considering the further facts that this is much more than the number of women actually sterilized, that most of the mutations are fatal and no offspring are produced and that among the visible mutations many are purely physiological without any pathogenetic character, it can readily be seen that there is very little danger of future generations being injured by the irradiation.

On irradiation with doses up to 100 r, according to what is known at present, injury of the germ plasm is not impossible but highly improbable.—*Audrey G. Morgan.*

Druckmann, Adolf. Ruckbilding einer Exostose durch Röntgenbestrahlung. (Retrogression of an exostosis under roentgen irradiation.) *Strahlentherapie*, 1932, *44*, 593–594.

A young woman of twenty-five came for treatment on account of pain in the left shoulder joint. Roentgen examination showed an exostosis with irregular and indistinct edges on the middle of the median border of the scapula. She was given roentgen treatment to relieve the pain. Doses of 3 H were given through a dorsal field with 0.5 mm. copper and 1 mm. aluminum filter on July 20 and 27 and Aug. 4. The pain stopped and the patient was discharged with no thought that the exostosis had been affected by this small dose. She returned for another examination on Dec. 11 because she feared tumor, though she had no pain or symptoms of any kind. The exostosis had decreased in size and become conical instead of mushroom-shaped and uniform in structure.

The irregular and indistinct edges and the fact that the patient had only had pain for two weeks before she came for the first examination indicated that the exostosis was a young and growing one. The roentgen irradiations had evidently brought about its consolidation and partial absorption. The theory of spontaneous retrogression might be advanced but no such

cases of spontaneous retrogression are known in the literature.—*Audrey G. Morgan.*

BUTLER, CARLOS. Behandlung des Basedow mittels Curietherapie und ihre Ergebnisse. (Treatment of Basedow's disease with radium and its results.) *Strahlentherapie*, 1932, *45*, 171–176.

The results of radium therapy in 65 cases of Basedow's disease are discussed. There were 27 cured, 23 improved, 4 still under treatment and 11 who gave up the treatment. This makes 41.53 per cent of the total number cured and 35.38 per cent improved. But counting out the 4 still under treatment and the 11 who stopped treatment leaves only 50 cases and the percentages for cure and improvement are 54 and 46 per cent. Seven of the improved cases would probably have been cured if they had continued treatment. Counting these cured gives 62.79 per cent cures.

There is almost immediate improvement in the nervous symptoms, such as tremor, palpitation and tachycardia. The menstrual and digestive disturbances are also cured and the patients gain weight and feel perfectly well. The hypertrophy of the thyroid and the exophthalmos persist longest and in some of the cases they did not disappear entirely. Basal metabolism determinations were made as an index of cure.

The radium was applied externally using flat or cylindrical apparatus. Radium sulphate plates 9 sq. cm. in area and weighing 22.5 mg. were used for flat apparatus and tubes containing 20 to 50 mg. radium salt as cylindrical apparatus. Their walls were of aluminum 0.5 mm. thick. The filter first used was 2 mm. lead and later platinum. The secondary filters were gauze and rubber, paraffin or Columbia paste and the distance from the skin 3 cm. The applications were for twenty-four to forty-eight hours depending on the amount of radium used. This technique caused radium dermatitis with telangiectases in some of the cases until the secondary gauze filter was replaced by paraffin or Columbia paste.

In severe cases injections of radium serum each containing 3 to 15 mc. were given twice a week. The duration of treatment varied from three to thirty-three months. The time required for treatment was proportionate to the severity of the disease. The average time was twelve months with 12 applications.—*Audrey G. Morgan.*

BORAK, J. Die Beziehungen zwischen der Strahlenempfindlichkeit maligner Tumoren und ihrer Muttergewebe. (Relations between the radiosensitiveness of malignant tumors and their mother tissue.) *Strahlentherapie*, 1932, *44*, 601–654.

In the radiotherapy of malignant tumors the constitutional and conditional factors which have an effect on the radiosensitiveness of tumors must be determined.

The constitutional factors result from the nature of the tumor or its mother tissue and the possibilities of radiotherapy in any given kind of tumor are dependent on them. It is first necessary to determine from what mother tissue the tumor in question originates and whether this mother tissue can be destroyed by irradiation without necrosis of the surrounding tissue. If it is a mother tissue that can be destroyed without injury of the neighboring tissue the dosage necessary for this destruction must be determined. If it is a mother tissue that cannot be destroyed without injury of the surrounding tissue it is necessary to determine whether it is an absolutely or only a relatively immature tumor or whether metaplasia has occurred.

The conditional factors of radiosensitiveness depend on the nature of the surrounding tissue or the regional and distant organs and the possibility of radiotherapy in the individual case must be judged from them. It is necessary to determine whether the neighboring tissues are infiltrated with tumor, whether they have been injured in any other way as by infection, operation or irradiation and whether there are any local or distant metastases.

In addition to these radiobiological factors there are clinical and radiophysical factors which play a part in determining the indications and prognosis as well as the plan of treatment in malignant tumors and a report will be made on them later.—*Audrey G. Morgan.*

NEMENOW, M. Über Geschwülste embryonalen Baues—Embryozytome—und ihre Radiosensibilität. (Tumors of embryonic structure—embryocytomas—and their radiosensitiveness.) *Strahlentherapie*, 1932, *44*, 655–678.

Most malignant tumors are not very sensitive to irradiation. There are malignant tumors of great radiosensitiveness, however, in different organs, chiefly in the endocrine glands. Cases of such radiosensitive malignant tumors

in the testicle, ovary, thymus, parotid gland and hypophysis are described. These tumors are all very much alike in their histological structure. There are other tumors of the same morphology, however, which are resistant to irradiation.

It is impossible to classify these tumors as carcinomas or sarcomas according to their morphology. They must be classified in a special group which the authors call malignant embryocytomas. They may be divided into two subgroups, one sensitive and one resistant to irradiation. The degree of differentiation of the cells can be judged from their radiosensitiveness. The cells of the radiosensitive tumors are not highly differentiated.

The radiosensitive embryocytomas and their metastases have a decided capacity for infiltrating the surrounding tissues along the interstices without destroying them by proteolysis. The embryocytomas resemble some lymphosarcomas in their degree of radiosensitiveness and their method of infiltrating the surrounding tissues. Some bone tumors also (Ewing's sarcoma) and many tumors which have been classified as endotheliomas belong in the group of radiosensitive embryocytomas.

The roentgen rays act on the finer structure of the cells—their molecules and atoms—and therefore it is as a rule impossible to judge their radiosensitiveness from the histological picture which only represents the gross structure of the cells.—*Audrey G. Morgan.*

Duffy, James J. Carcinoma of the tonsil; a review of 122 histologically proven cases treated 1921 to 1928, inclusive. *Surg., Gynec. & Obst.*, March, 1932, *54*, 539–550.

These lesions constituted 2.23 per cent of the malignant tumors included in the survey made by Pack and LeFevre, of 19,129 cases admitted to the Memorial Hospital, New York City. Of the intraoral group of tumors, carcinoma of the tonsil accounted for 9.64 per cent, more than ten times the incidence of lymphosarcoma of the tonsil.

The most common symptom is pain, especially on swallowing, with an irritation or soreness of the throat and occasionally pain referred to the side of the head. In cases in which pain is referred to the side of the head, the lesion infiltrates deeply and there is considerable extension into the base of the tongue, or there is a mass in the cervical region, which infiltrates around the upper branches of the cervical nerves. There may be cervical metastasis from an apparently insignificant lesion in the tonsil, particularly when the primary lesion is a transitional type of cell.

Carcinoma of the lower grades of malignancy are more apt to ulcerate and extend locally, while transitional cell carcinoma, lympho-epithelioma and lymphosarcoma ulcerate less frequently but metastasize rapidly.

Treatment. Duffy briefly reviewed the scanty literature upon surgical treatment of carcinoma of the tonsil and concludes that carcinoma of the tonsil in any stage is primarily surgically inoperable. Bloodgood has said that he has not cured a case of carcinoma of the tonsil by surgery.

The author presented 122 cases of carcinoma of the tonsil treated at the Memorial Hospital between the years 1921 and 1928, inclusive, of which, 29 per cent were classified as early and the remainder were advanced. Fifty-eight per cent of the cases had definitely palpable metastases when admitted. The location of these metastases was in the deep cervical group in 63.7 per cent; the node overlying the carotid bulb in 13.2 per cent; the node in the posterior submaxillary region in 6.6 per cent; the nodes on the opposite side to the primary lesion in 3.3 per cent; the nodes on both sides in 9.5 per cent, and the whole chain of nodes on the same side as the lesion in 3.3 per cent of the cases with metastases on admission.

Only those patients treated up to 1925 were included in the five year group. Of those 49 cases, 13 had no cervical nodes throughout, and 5, or 38.4 per cent, are well; 13 developed metastases after admission and none is well; 15 had operable nodes on admission and 4, or 26.6 per cent, are well, and 8 had inoperable nodes on admission and 1, or 12.5 per cent, is well. These represent patients well for five years or more and gives an average of 20.4 per cent of all cases, regardless of the stage of the disease, as well five years or more.

The technique employed by the author is as follows: The treatment of carcinoma of the tonsil consists of a combination of external and interstitial irradiation. Each side of the neck is subjected to high voltage roentgen therapy, the beam including both the primary lesion and the lymph drainage areas. Immediately following these exposures a radium pack is directed over the primary lesion and the adjacent cervi-

cal region. These irradiations are given in full erythema dosage. This amount of radiation delivers 150 to 180 per cent of a skin erythema dose to the tonsillar growth. A varying amount of radon is then implanted into the neoplasm, depending on its size and configuration.

If operable cervical metastases develop, or if they are present at the time of admission, a neck dissection is done when the skin reaction from the external irradiation has subsided and the primary lesion is nearly healed. If the primary growth is a very radiosensitive type, radical surgery of the nodes is not undertaken; dependence is placed upon the surgical exposure of the node and radon in full dosage implanted in gold tubes. In the more advanced cases, the interstitial radiation is buried through the skin without incision.—*J. H. Vastine.*

Burnam, Curtis F. Diagnosis and treatment of malignant tonsil conditions. *Surg., Gynec. & Obst.*, Nov., 1932, *55*, 633–639.

The diagnosis and treatment of malignancies of the tonsil present problems quite similar to those of neoplasms of the posterior surface of the tongue, of the pharynx, and nasopharynx. The tumors are similar in histology, difficulty of diagnosis, clinical course, and general impossibility of adequate surgical treatment. In general, the progress of the disease is rapid and the glands are involved early, 70.3 per cent of the 165 cases reported by Burnam having palpable nodes when coming under treatment.

Symptoms. The most common initial symptom is pain which may be local but which more often radiates to the ear, neck and head. The appearance of a glandular mass in the neck was occasionally the first observed evidence of the disease. Discomfort on swallowing has been the initial symptom in some cases and has persisted for months before a visible lesion has appeared.

Diagnosis must rest ultimately on a microscopic examination. Differentiation must be made from syphilis, tuberculosis and Vincent's infection, all of which are quite common. Primary Hodgkin's disease of the tonsil is not uncommon.

Types of Malignancy. Metastatic malignancy to the tonsil is rare. The author observed 3 cases, 2 adenocarcinomata from the breast and one very malignant embryonic type of adenocarcinoma from the testicle.

The primary tumors may be divided into the mixed tumors, the epitheliomata and the sarcomata.

The mixed tumors are similar in histology and clinical course to the mixed tumors of the parotid. These the author believes to be of low malignancy, radioresistant and more amenable to operative removal. Berven reported on 5 cases treated by combined radium and operation with 3 five year cures.

Epitheliomata. These are usually of a high grade of malignancy. Broders classified 94 per cent of these cases at the Mayo Clinic as belonging to grade 3 or 4. In contrast to this, Ewing found 72 per cent of 200 cases to belong to radioresistant neoplasms, and Coutard found 62 per cent of 47 cases to be resistant. Ewing classifies epitheliomata of the tonsil into squamous or spinous cell epitheliomata, transitional cell epitheliomata, and lympho-epitheliomata. The squamous cell epitheliomata vary in histological appearance from those composed of adult cells to anaplastic growths which can hardly be distinguished from sarcomata. Transitional cell epitheliomata are made up of sheets of large, pale, delicate cells, with large nuclei and indefinite outlines. Lympho-epitheliomata were described in 1921 by Schminke and Regaud independently. They are, histologically, very similar to the transitional epithelioma, but include rapidly proliferating lymphoid tissue which gives the same histological impression as lymphosarcoma.

Sarcomata of the tonsil are principally lymphosarcomata.

Treatment. Since Matthews' report, in 1912, of the surgical results obtained in treating malignant tumors of the tonsil, there have been no satisfactory reports of extensive series of cases from a single clinic. The radiation treatment, however, is fairly well recorded. Schreiner reported on 60 cases treated between 1915 and 1925 with 2 living three years or more. Quick reported on 318 cases treated between 1918 and 1928 with 28 living three years or more. Coutard reported on 47 cases with 7.7 per cent cures in epidermoid epitheliomata and 62 per cent in other cases. Neu reported 4 of 15 cases as living more than one year following cautery, radium treatment and block dissection of the neck. Berven reported 4, or 28.6 per cent, of three year cures in 14 cases treated by surface radium, interstitial radium and teleradium. The author reports 9.75 per cent of 123 cases treated between 1911 and 1927 as living and apparently well. In the cases which could be traced and in which there was healing of the primary tumor obtained, 50 per cent of sarcomata and

12.9 per cent of the epitheliomata remained well five years or more.

Technique. Burnam employs interstitial irradiation for treatment of the primary lesion, crossfiring the affected tonsil as well as the regional lymph drainage with teleradium employing 25 gram-hours at 10 cm. distance through each portal, four or five such portals being employed. Berven is convinced that the effects of teleradium are very much superior to those obtained by roentgen irradiation. Coutard has obtained excellent results with roentgen irradiation alone. Burnam favors the use of radium and attributes its effects to the slow, continuous irradiation over several weeks as contrasted to single intense exposure as often employed in roentgen therapy.—*J. H. Vastine.*

New, Gordon B., Broders, Albert C., and Childrey, John H. Highly malignant tumors of the pharynx and base of the tongue. *Surg., Gynec. & Obst.*, Feb., 1932, *54*, 164–174.

The most common malignant tumors of the pharynx and base of the tongue are the lymphosarcomata and the squamous cell epitheliomata graded 3 or 4. The authors discuss the lympho-epithelioma and transitional cell carcinoma and state that these are both the same tumors and are in reality squamous cell epithelioma, graded 4.

The present review covers 624 of 1,393 patients with such tumors seen at the Mayo Clinic over a period of 14 years. Only those cases were included which were microscopically proved. Of these cases, 78, or 1 in 10, were lymphosarcomata, 267 were squamous cell epitheliomata, graded 4, and 279 squamous cell epitheliomata, graded 3.

In 31.8 per cent of 194 cases of lesions of the nasopharynx, there was cranial nerve palsy with an average involvement of about three nerves. The sixth, fifth and ninth nerves were those most often affected. Grade 3 epithelioma most frequently involved the nerves. Lymphosarcoma, a softer and bulkier type of neoplasm with less tendency to infiltrate, involved the nerves less often.

The authors give numerous factors which influence the treatment showing the necessity of individualization. The authors only found 182, or 29.15 per cent, of the 624 microscopically proved cases favorable for treatment.

Lymphosarcoma is more malignant and more radiosensitive than the active type of epithelioma. A large proportion of epithelial growths of the pharynx and tongue are of an undifferentiated, radiosensitive type of cell structure. Operation, diathermy or cautery is still being used for these lesions which might better be treated by irradiation alone. It is possible that these lesions may be activated by incomplete surgical procedures. Localized, accessible lesions of the tonsil, tongue, or pharynx may be excised surgically or by diathermy or cautery, followed by the insertion of radium directly into the wound. In the lower grade lesions, this is followed by surgical removal of the lymph nodes of the neck which drain this area. If the primary lesion is extensive, with or without large lymph nodes, irradiation probably offers the only chance. For lesions in the nasopharynx, surface applications of radium are indicated.

About 16.5 per cent of all patients treated are alive three years or more.—*J. H. Vastine.*

Stähler, Fritz. Ein neues Zielinstrument zur Erleichterung des Einstellens bei gynäkologischen Tiefbestrahlungen. (A new aiming instrument to make focusing easier in gynecological deep irradiation.) *Strahlentherapie*, 1932, *44*, 475–480.

In the treatment of carcinomas of the female genitalia the rays have to pass through thick layers of normal tissue. The author's clinic generally uses four fields, two ventral and two dorsal, about 80 to 150 sq. cm. in area and sometimes in addition a vulvar or an intestinal field. The rays have to be directed on these fields at an angle of 4°–5° and it is very hard to adjust the tube so as to be certain that the central ray strikes the tumor.

An instrument is described and illustrated by means of which it is possible to direct the rays on the tumor and also to determine the depth of the tumor. The illustrations show clearly the method of using the instrument. Its construction and use are very simple so that it is a valuable aid in practice.—*Audrey G. Morgan.*

Schmitt, Walter. Behandlungserfolge beim Kollumkarzinom nach Operation und nach Bestrahlung. (Results of operation and irradiation in cancer of the cervix.) *Strahlentherapie*, 1932, *44*, 401–420.

The Würzburg Clinic up to the middle of 1923 operated on all operable cases, while in-

operable cases have been given radiotherapy since 1913. The Clinic was under the same director for all these years. It has been more than five years since the end of the period so the five year results are known in all the cases.

The total number of cases of carcinoma of the cervix from Jan. 1, 1913 to June 30, 1923 was 305. Of these, 120, or 39.3 per cent, were operable, and operated on. The Freund-Wertheim operation was performed in 23 cases, extensive vaginal total extirpation of the uterus in 95 and supravaginal amputation of the cervix in 2. Among the 23 Freund-Wertheim cases there was primary death in 3, or 13 per cent, and 11, or 47.82 per cent, remained alive longer than five years. The other 9 died within one to four years after the operation. The relative permanent cures therefore were 47.82 per cent. Among the 95 cases of vaginal total extirpation there were 13 deaths, or 13.6 per cent, and 38 remained alive more than five years, or 40 per cent relative permanent cures. Of the 2 cases in which supravaginal amputation of the cervix was performed one was given roentgen and radium after-treatment and died two years after the operation, the other was not given postoperative irradiation and died four years after operation. Dividing the 118 cases of radical operation according to the stage of the disease, among the 73 in the earlier stages, 50.8 per cent were permanently cured while among the 45 in the later stages 26.6 per cent were permanently cured.

Most of the cases were given radiotherapy after operation. Among the 23 cases of abdominal operation there were 20 primary recoveries. Of these, 14 were irradiated with roentgen rays alone; 9, or 64.3 per cent, of these remained alive more than five years, while of the 6 that were not irradiated 2, or 33.3 per cent, remained alive more than five years. Among the 95 cases of radical vaginal operation there were 82 of primary recovery. Among these, 63 were irradiated and 26, or 41.3 per cent, recovered permanently. Among the 43 cases irradiated with radium alone, there were 48.4 per cent permanent recoveries, among the 8 irradiated with roentgen rays and radium combined 25 per cent and among the 11 irradiated with roentgen rays alone 36.4 per cent. Among the 19 cases not given after-irradiation there were 12 permanent recoveries, or 63.1 per cent.

Among the total 118 cases of radical operation there were 102 primary recoveries, 77 cases of after-irradiation with 45.5 per cent permanent recoveries and 25 cases not irradiated with 56 per cent recoveries. The figures are too small of course to permit of definite judgments as to the value of postoperative irradiation, particularly as in many cases only small doses of irradiation were used.

Irradiation was given before operation in 9 cases, all of them far advanced. The irradiation rendered operation possible and in all but one of these cases radiotherapy was given after operation also. Five of the patients, or 55.5 per cent, remained alive longer than five years.

Counting the whole number of operated cases the figures for relative permanent cure were 40.8 per cent (49:120) while for the 118 radical cases they were 41.5 per cent (49:118).

Among the 185 inoperable cases 163 were given radiotherapy. Of these 14 remained alive after more than five years, or 8.58 per cent.

For the total 305 cases the result of combined treatment—operation of operable cases and radiotherapy of inoperable ones—was a relative permanent recovery of 63:305, or 20.6 per cent. Counting out the 22 untreated cases, the absolute figure was 63:283, or 22.2 per cent.

The figures for the years 1899 to 1913 are also given and a comparison shows that with the development of operative technique and increasing confidence in surgery the percentage of operations increased. The primary mortality for the second period (1907–1909) sank to about a third that of the first period. But in the third period (1910–1912) when the limits of operability were extended still further and 73.6 per cent of the cases were operated on the primary mortality rose to 21.8 per cent. But in spite of this very high primary mortality the absolute figure for permanent cures was 24.4 per cent. When radiotherapy was begun in 1913 more caution was again used in the choice of operative cases and only 39.3 per cent of the cases admitted were operated on. The primary mortality fell to 13.3 per cent and the relative permanent cures after operation rose to 40.8 per cent. But in spite of radiotherapy of inoperable carcinomas which had necessarily remained completely untreated up to 1913, the absolute figure of 20.6 per cent remained less than that of the previous periods. The absolute figures for permanent cures were best in those years in which the limits of operability were extended most.—*Audrey G. Morgan.*